Issued under the authority of the Home Office
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Fire Service Manual

Volume 2
Fire Service Operations

Marine Incidents

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Volume 2
Operations

Marine Incidents

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HM Fire Service Inspectorate Publications Section
London: The Stationery Office

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ISBN 0 11 341231 2

Cover photograph:
Northern Ireland Fire Brigade

Half-title page photograph:
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Printed in the United Kingdom for The Stationery Office
J84831 6/99 C50 5673

Preface

This book, Fire Service Manual, Volume 2, Fire Service Operations – Marine Incidents, supersedes Part 2 of book 4 of the Manual of Firemanship. The guidance provided replaces and updates, as appropriate, information previously published on this subject.

Previous editions of the **Manual** have described fireboats and seamanship, but as there are now very few such craft in use with Brigades these subjects are no longer included. Each Brigade with a boat must devise its own specific training and procedures, arrange liaison with relevant authorities and ensure compliance with appropriate local, national and international rules of operation.

Some Brigades have arrangements with tug companies to use their tugs for firefighting, and this aspect is briefly covered.

Safety is of paramount importance. The need for the consideration and implementation of suitable measures, as outlined in the **'Fire Service Guides to Health and Safety'** (see 'Further Reading') should always be borne in mind by all personnel when attending operational incidents.

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Introduction

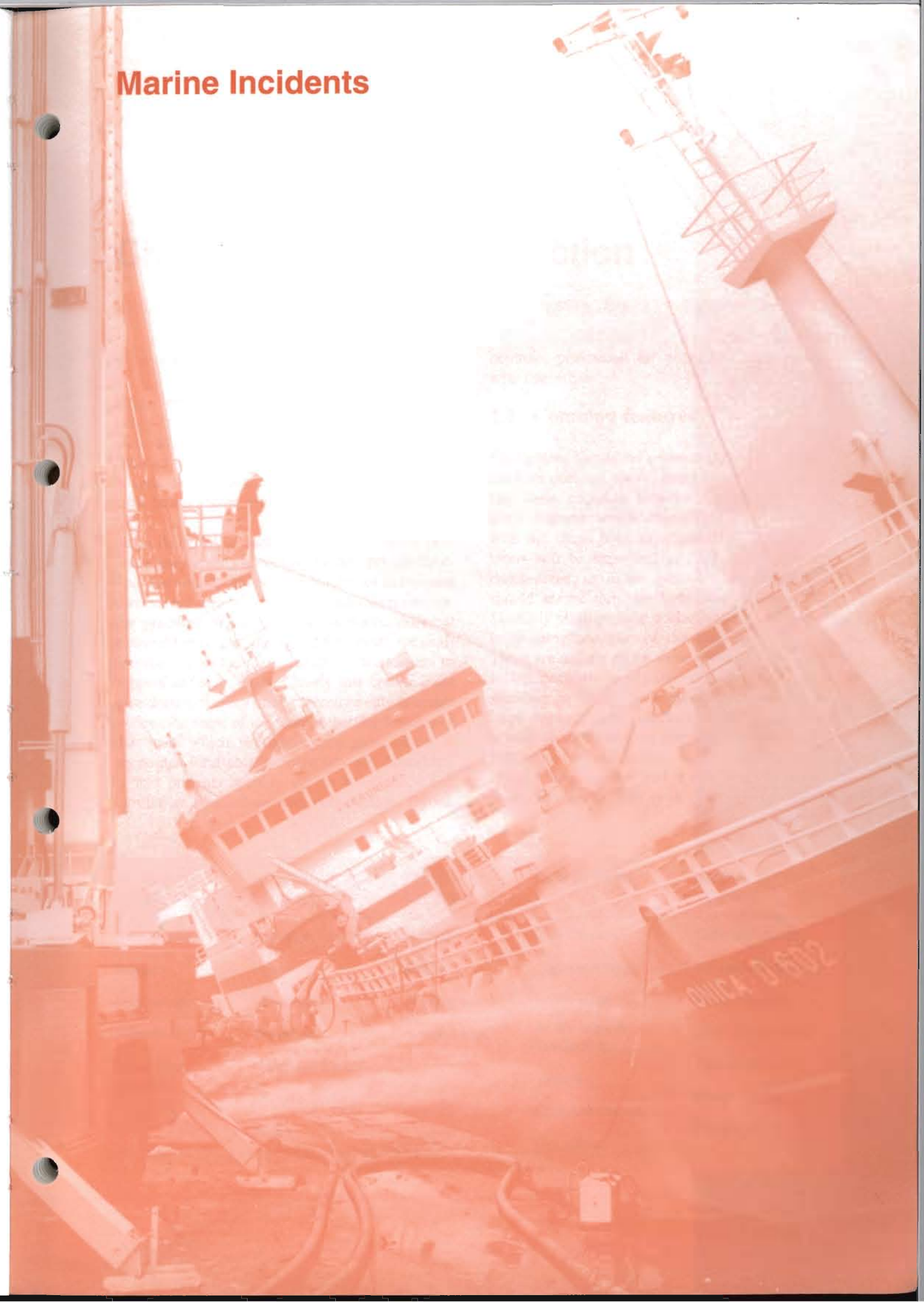
Fires on board ships can be both complex to deal with and at times, may test the expertise of firefighters and their physical endurance. Such incidents almost always present the Fire Service with difficult problems. In port, firefighters will have to take into account such factors as the type of ship, the location of its berth, whether it is loading, unloading, refitting or under repair, its cargo, the degree of accessibility and the availability of fireboats or fire tugs. At sea there will be problems of getting personnel and equipment aboard.

The increase in shipping generally has made incidents more likely, particularly those resulting from collisions, and these incidents may be complicated by the presence of dangerous materials, the carriage of which is continually increasing. Any coastal Fire Brigade might find itself faced with a major incident, and even brigades without a coastline could have to deal with incidents on canals and navigable rivers.

To cope effectively with such incidents firefighters require a good background knowledge of shipping generally. Brigades must also ensure that familiarisation systems are in place so that personnel are made aware of any particular risks in their own areas (including transient or temporary risks). Liaison with the relevant authorities, commercial organisations etc., is essential, as is adequate preplanning.

This book looks initially at ship construction in general and describes the principal types of ship which firefighters are likely to encounter. The maritime legislative controls covering fire protection provision on board merchant ships are outlined together with the basic requirements for the different types of vessel. The fundamental principle of the important, but complex subject of ship stability is also covered. A section on the strategy and tactics of fighting fires on ships is followed by further guidance for tackling fires involving different types of vessels, with different cargoes, both in port and at sea, and the various factors involved are considered. The issue of liaison and preplanning, which necessarily involves the sometimes contentious area of responsibility at ship fires, is discussed in some detail. Advice is given on how to identify and deal with dangerous cargoes. Particular problems relating to inland waterways, marinas, historic ships and floating restaurants are also covered. A chapter on training and safety gives details of managing marine incident safety and basic training requirements. At the end of the book is a glossary of the special terms used in connection with shipping.

Marine Incidents



Chapter 1 – Ship Construction

The variety of shipping

Ships serve various purposes, the most common being the carriage of different natural and manufactured goods, the carriage of passengers, the conduct of military operations, fishing, sport and leisure, and assistance to other navigation. The table below shows some of the main divisions.

Ships designed or adapted for each of these purposes vary greatly according to their precise function; the volume of goods or number of passengers carried; the requirements of the individual owners; the practices of different ship-builders; different national legislation; the age of the vessel; the preferences for different materials or techniques to achieve the same ends. Clearly this book cannot give details of every one: it therefore only attempts to describe some of the more important features of the types which firefighters are most likely to encounter. Firefighters should take any opportunity that presents itself to get on board ships and familiarise themselves with construction, layout, controls, provisions for preventing and dealing with fire, etc.

WARSHIPS	PASSENGER & LEISURE	FISHING VESSELS	CARGO SHIPS	SPECIALIST VESSELS
Aircraft carrier	Passenger Cruise Ship	Trawlers	Bulk Carriers	Cable laying ship
Frigate	Ferries	Drifters	Containers ships	Research vessels
Minesweeper	Catamarans	Whaling ships	LASH ships	Salvage vessels
Submarine	Hovercraft	Factory ships	Ro-Ro ships & Sto-Ro Ships	Buoy Tender vessel
Royal Fleet Auxiliary	Combined Carriers		Tankers	Prison Ship
	Hydrofoil vessels		Chemical Carriers	Historic Ships
	Yachts		Gas carriers	Dredgers

1.1 Common features

Firefighters should be aware that despite the differences outlined above, many ships do have certain basic common features. Figure 1.1 shows some features which most ships have, together with the terms used in referring to them (other terms will be explained in the text as they are encountered, or in the glossary, and firefighters should ensure they are familiar with them all). Similarly all ships have decks (floors), horizontally dividing one part of the ship from another. These are usually of the same material as the vessel but, particularly on passenger vessels, are often sheathed in timber or a plastic composition. In large ships of metal construction the steel plating is built up on a series of ribs; there are watertight bulkheads (vertical walls), dividing the interior of the ship into sections, and at each end of the ship there is a fore or after peak (Figure 1.1) used to

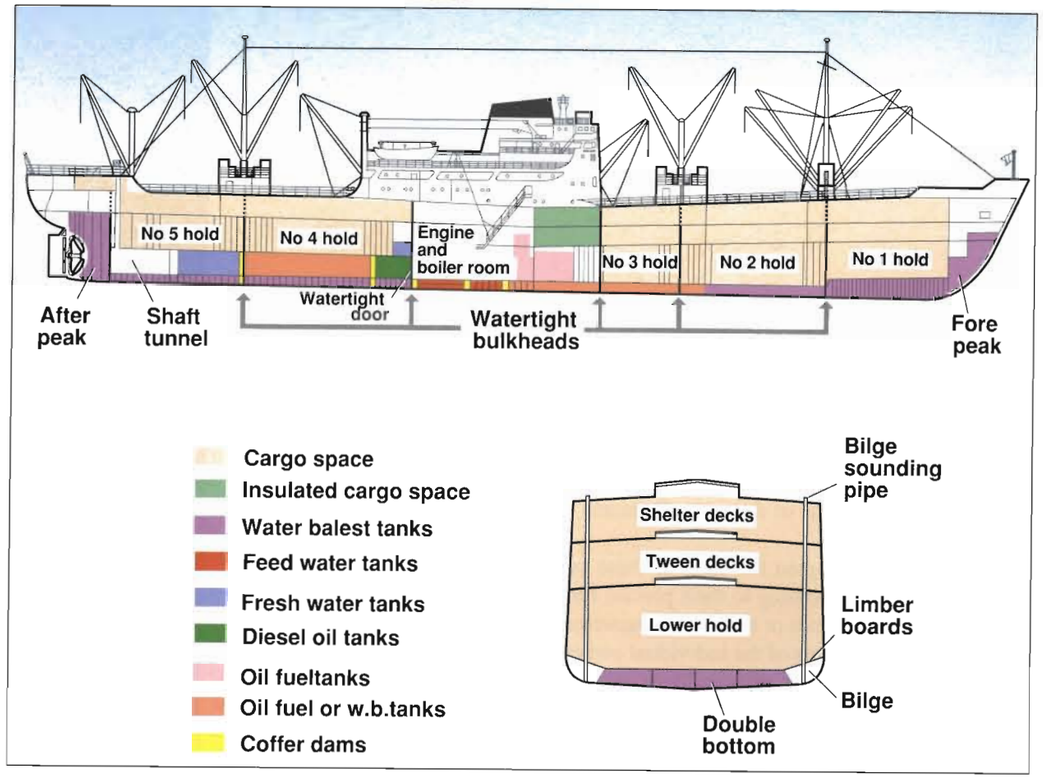


Figure 1.1 Section through a cargo ship with shelter and 'tween deck, showing the lay-out of holds, machinery spaces etc.

carry stores, water ballast, or occasionally fresh water supplies. On some modern ships the superstructure may be of lightweight aluminium alloy rather than steel, but generally this material is more likely to be found on the smaller fast passenger craft such as catamarans or Royal Naval vessels. Plastics are being used more for a wide range of purposes: structural features, fittings and, in accommodation areas, decoration. Such materials can create special firefighting problems: the plastics for instance can produce smoke and toxic fumes rapidly and in large quantities.

1.2 General Cargo Ships

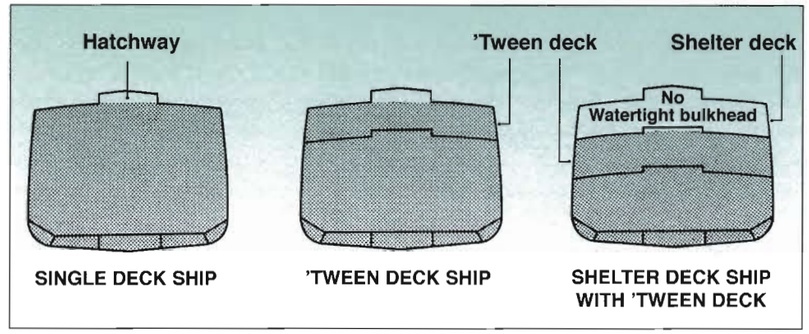
(a) Ship decks and holds

(Arrangement of decks and holds)

Figure 1.1 shows a typical general cargo ship, designed to carry the largest possible number of goods. The holds, numbered from bow to stern, may be as many as eight but more usually five for vessels engaged deep-sea, or less on those engaged in coastal traffic. There may be oil fuel and water ballast tanks at their sides, more especially towards the ship's centre. More modern ships tend to have their machinery towards the stern (Figure 1.6), older ones towards the centre, but this does not affect the general principles of the design.

Normally each hold is separated from adjoining spaces by watertight steel bulkheads running across the ship, any openings in these being fitted with watertight doors. On the simplest ships each hold is a single compartment between two bulkheads, extending from the inner bottom to the upper deck. On more complex ships there are additionally one or more intermediate or 'tween decks, some of which may exist between certain bulkheads only. 'Tween decks may themselves have longitudinal bulkheads running on the centre line

Figure 1.2 Sections through three common types of cargo ship.



of the ship, or other means of sub-division. In a few vessels the transverse (across the width of the ship) bulkheads between the holds do not extend as far as the upper deck but terminate at the one below. The upper deck is known in such a case as the shelter deck, and the space immediately below it is known as the shelter 'tween-decks (Figure 1.2). This is essentially an open area, but may have some means of partitioning if desired.

There are various superstructures above the uppermost continuous deck; design, layout etc., vary from ship to ship. Part of the superstructure will comprise the bridge (the platform from which the vessel is steered, navigated and controlled); the remainder may be used for cargo, stores, machinery or accommodation.

(b) Hatches

In the deck over each hold is a large opening or hatchway to give access for loading and unloading; sometimes there is more than one. These openings usually extend across the deck for about one third of the beam, but may be much wider. 'Tween decks have similar openings, usually in a direct vertical line. All are protected by hatch covers. On the upper deck, these are usually of a watertight, steel construction with hydraulic or electric operation. There are various designs (Figure 1.3). 'Tween deck hatch covers may be similarly operated, but flush-fitting, as in type 2 of Figure 1.3, or may consist of separate steel sections like the individual leaves of types 3 and 4. The sections are usually flush to the deck and are not self-powered but have to be lifted by cranes. All hatch covers are designed to take the weight of cargo: on the upper deck this may consist of containers stacked up to four high. Heat can distort the metal of hydraulically/mechanically/electrically operated hatch covers and make them inoperable; in such cases they must be manually forced.

(c) Means of access to 'tween decks and holds

The most common means of access are:

(1) **Ladders**
These are the principal means. Usually they lead down from one side or end of a hatchway; sometimes they are reached by a separate small or booby hatch. The ladders may be staggered at different deck levels.

(2) **Mast houses**
Trunkways may lead from a mast house on the upper deck to the lower hold (Figure 1.4). These contain ladders giving access to the various decks, the lower hold and the double bottom. They may also act as ventilators, with cowls on top of the mast house (see below).

(3) **Trimming**
These are small openings, usually about 600mm square, which are sometimes found in the 'tween decks in the far corners from the main hatches.

(4) **Hatches**

(5) **Bilges and tanks**
Water from the bottom of the hold, and usually any from the 'tween decks, perhaps with oil residue, drains down to bilges at the outer edge of the

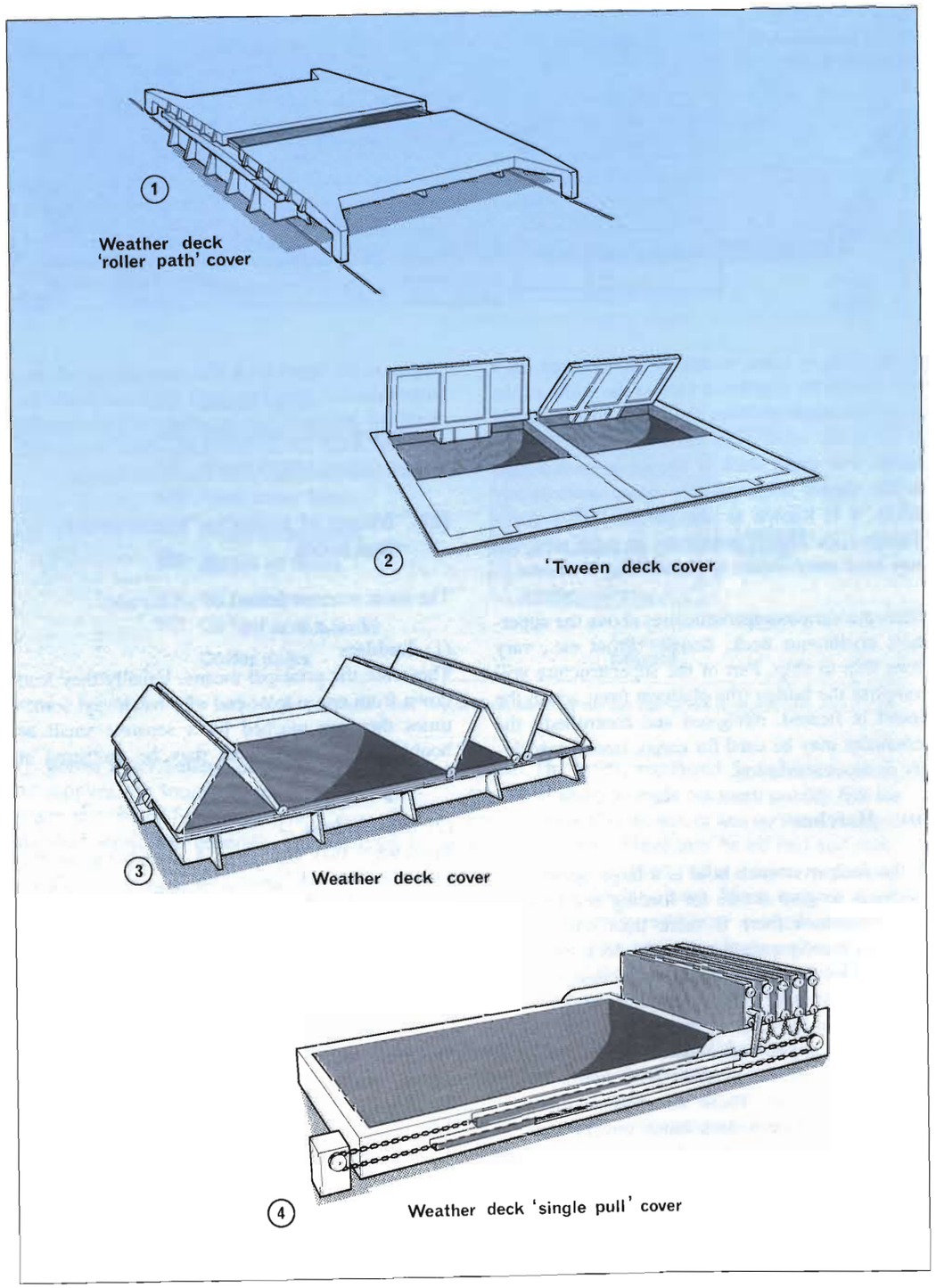


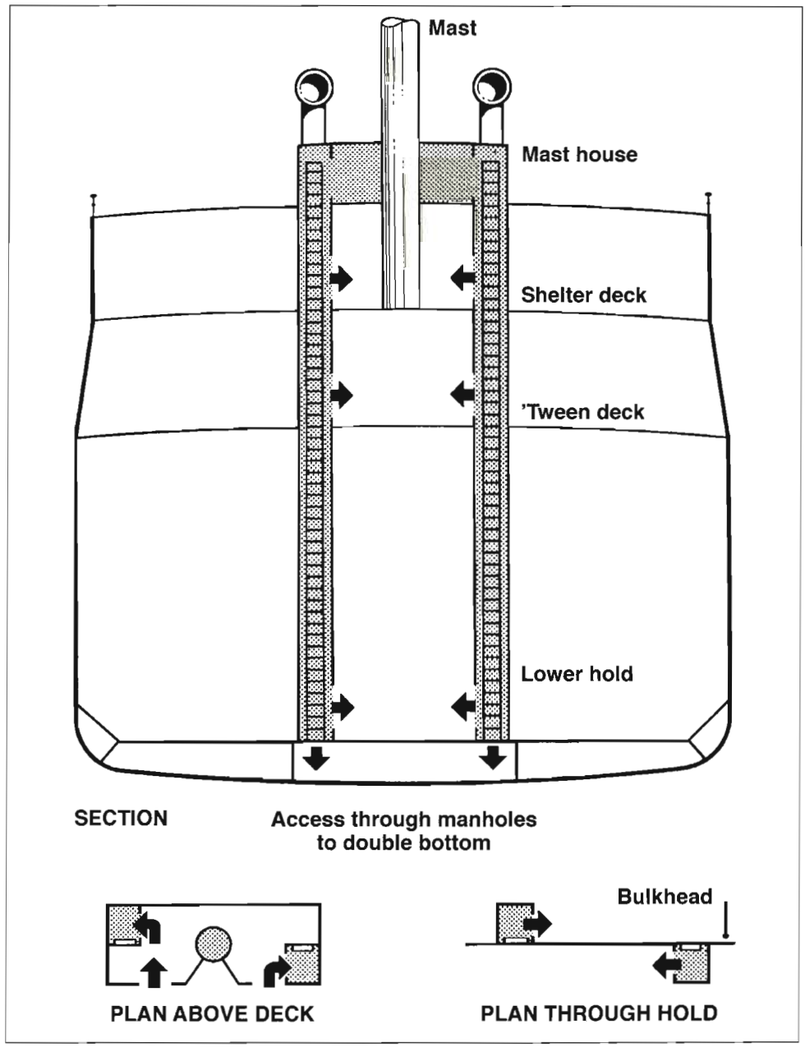
Figure 1.3 Diagrams showing various types of hatch covers found on cargo ships.

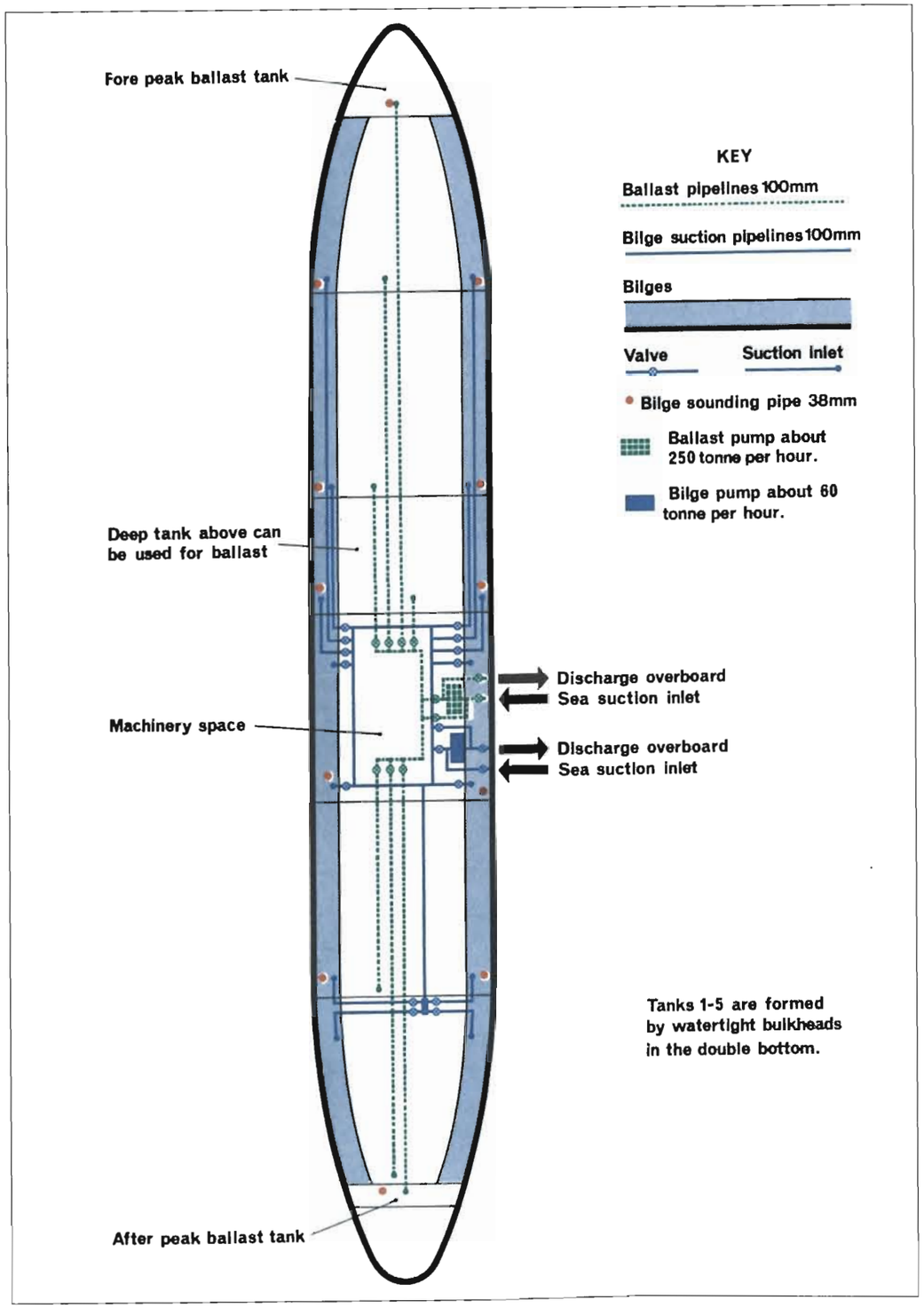
double bottom tanks or into sumps in the tank tops. The water is pumped out through pipelines connected to bilge pumps in the machinery space. Bilge sounding pipes, one for each side of each hold, enable measurement of the water depth. Sounding pipes may also be utilised for lowering thermometers when assessing a fire in a cargo hold. Bulk carriage of coal is susceptible to fires and it would be a daily routine to measure and log these temperatures. There is also likely to be access to the bilges via hatches from the lowest deck (Figure 1.4).

(6) **Ventilators**

Most modern cargo ships have mechanical ventilation of holds, with supply and exhaust fans. On some older vessels, however, there may be a free flow air system, using cowl ventilators. In this system, shafts lead to the below-deck areas from above deck cowls which can be rotated into and out of the wind. Some cowls are fitted with steel flaps which can, if necessary, be closed to prevent the entry of air; in other cases the cowl can be lifted off and the shaft blocked with a plug and canvas cover.

Figure 1.4 Section and plan of one type of mast house, and access to trunkways.





(d) Other ship features

(1) **Deep tanks**
A deep tank may replace the lower hold immediately in front of, and sometimes behind, the machinery space. It may carry water ballast, oil or cargo. (See also subsection (4) below). The deep tank hatch cover is bolted on, and can be removed if necessary, but access can also be obtained through a manhole cover.

(2) **Machinery spaces**
These basically consist of engine and boiler rooms shut off from the holds by watertight bulkheads. Modern ships have additional areas containing such items as pumps, electrical switchboards, switch gear etc. The engine room may, on older ships, be separated from the boiler room by a bulkhead, but this will be pierced by an opening which may not be watertight. The spaces have their own ventilation. On modern ships they are usually on the stern, in older ships at the centre. They can be reached by ladder from an upper deck; these have a steep pitch and could be greasy.

Although very few dry cargo ships are steam driven, about 7% of tankers, gas tankers, cruise and container ships are still powered by steam. The majority of ships have diesel engine propulsion and large diesel generators and pumps, so no longer have traditional boiler rooms. There may be small boilers and incinerators within the machinery spaces or in a separate compartment.

(3) **Shaft tunnel and tunnel escape**
A shaft tunnel runs from the engine room aft and contains the intermediate shafting between the engine and propeller shaft (Photo. 5.14). It is quite often used for the storage of paint, drums of lubricating oil, etc. A watertight door links the tunnel and the engine room; methods of opening vary but there is generally a wheel in the bulkhead of the accommodation area immediately above with local control. An escape trunk fitted with a ladder leads up from the tunnel to an upper deck. The ladder may lead down only as far as the tunnel deckhead, with hand and foot holds then leading to the tunnel floor. Ships with the engine aft may not have a shaft tunnel. There will then be a means of escape (or entry) from low level in the engine room.

(4) **Water ballast and fuel system**
Cargo ships must have provision for the carriage of water ballast since otherwise, when not fully loaded, they would present too large an area to the wind and have their propellers only partially submerged. As already noted, water ballast can be carried in the fore and after peaks and in the deep tank. Additionally, the hull of most ships has a double bottom space of 750–1200mm in depth, which is divided into watertight compartments. This provides a safeguard in the event of grounding and is also used for extra water ballast, feed water for the boilers and oil fuel. Fuel oil is carried in double bottom tanks or in the deep tank, or in the wing compartments and cross bunker spaces.

Figure 1.5 (Opposite) General lay-out of ballast tanks, pipelines and bilge suction pipelines of a typical cargo ship.

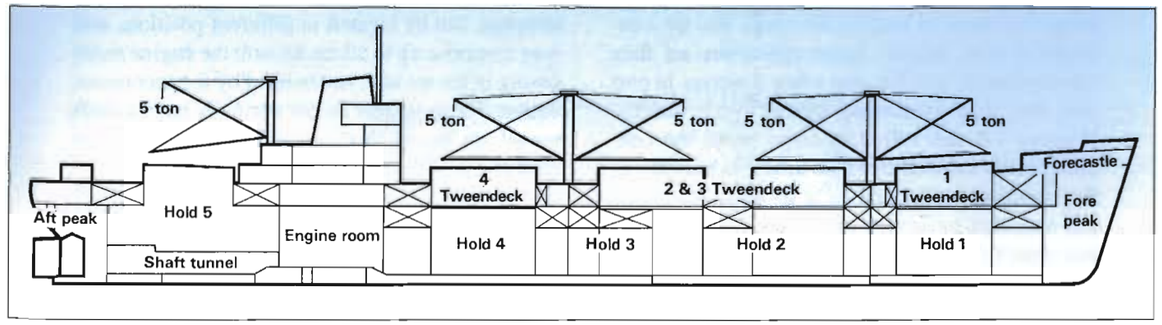


Figure 1.6 Modern general cargo ship. An escape trunk fitted with a ladder would run up from the shaft tunnel through the aft peak.

Marine diesel engines use heavy fuel oil which needs pre-heating. On Liquid Natural Gas ships any 'boil-off' from the cargo is used as engine fuel. Cofferdams usually separate compartments containing oil from those containing fresh water or cargo. They are double watertight bulkheads, usually transverse, with a space of about one metre between them.

From the fuel storage tanks, the oil is pumped to settling tanks in the machinery space and heated, then purified by means of a centrifuge before it is passed to the fuel pumps. The excess oil from the centrifuge or burners should collect in oil bilge holding tanks. According to the Safety of Life at Sea (SOLAS) Convention. (See Chapter 2: the oil should have a flashpoint not lower than 43 degrees C.)

Filling or emptying any tank (or cargo space) will affect the ships stability, especially if it has a free surface area of liquid. (See Chapter 4)

1.3 Container Ships

(a) Types

Previously, ships have carried their cargoes in bulk or as individual items. Nowadays, however, most packaged cargo is carried unit loads. The trend has been towards optimising the time a ship spends at sea carrying cargo (i.e. earning money) and minimising the time spent in port handling cargo. This is achieved often at the expense of efficient use of the space aboard ship. Even a ship which looks conventional may have doors in the side and lifts for loading palletised cargo with fork lift trucks. The logical development of this is containerisation where the work of loading the cargo into the container is done ashore. These containers are then rapidly loaded into the ship when it arrives in port and the ship is turned around very quickly (Figures 1.8 and 1.9). The cargo inside the container is not handled from the time it is loaded into the container until it arrives at its destination having travelled by several modes of transport. The equipment to handle the cargo, costing millions of pounds, is invested in the ports, the ship has no means of handling its own cargo and in some cases is unable to remove hatches without assistance from ashore.

The fact that the cargo is not actually handled on board the ship has reduced the number of fires, but the lack of lifting equipment combined with difficulties of access to the doors of the containers are what may cause operational problems with cargo fires on this type of vessel. Some container ships are 'open topped' and there are no hatches between the on deck cargo and the cargo below decks.

Containers are constructed to internationally agreed dimensions; the standard sizes are 6.1 × 2.44 × 2.44 metres and 12.2 × 2.44 × 2.44 metres, with a maximum carrying capacity of 20 and 30 tonne respectively. Containers are usually made of mild steel, stainless steel, steel-and-aluminium alloy, fibreglass, or combinations of these materials. They vary considerably in design: apart from the standard models for miscellaneous cargoes there are insulated and refrigerated containers, open-top models, bulk models and tank models (Figure 1.7 and Photo's 1.2 and 1.6). They may be of single or double wall construction. Containers may be found on road vehicles, railways, stacked in ports or at cargo handling centres or factories.

Container ships range in size from very large ocean going vessels (Photo's 1.1 and 1.4) which may carry over 6,000 containers to smaller feeder vessels which carry containers to and from the major ports in the area, and there are ships which have only part of their capacity for carrying containers, the rest being Ro-Ro, or conventional cargo space.

(b) Features

The design of container ships varies. The superstructure can be located in different positions and may comprise up to 12 decks with the engine room casing in the middle, surrounded by the accommodation. These vessels do not normally have a shaft tunnel, so access to the engine room is from the decks only (Figure 1.9). Access to the holds is via the very large hatches provided for loading and unloading, or from a working alley below the main deck on port and starboard sides; this has small hatchways fitted with ladders. There can be up to 12 holds, each having perhaps two or three loading hatches. On some types, the top containers rest on the upper deck, in which case the deck and hatch covers are strengthened to take the weight of the containers. Some holds are insulated (Section 1.6) and carry containers attached by flexible pipes to the ships refrigeration system. There may also be refrigerated containers on deck. These may have motors driven either by an integral diesel engine or by electricity fed through flexible cables from the ship's power installation.

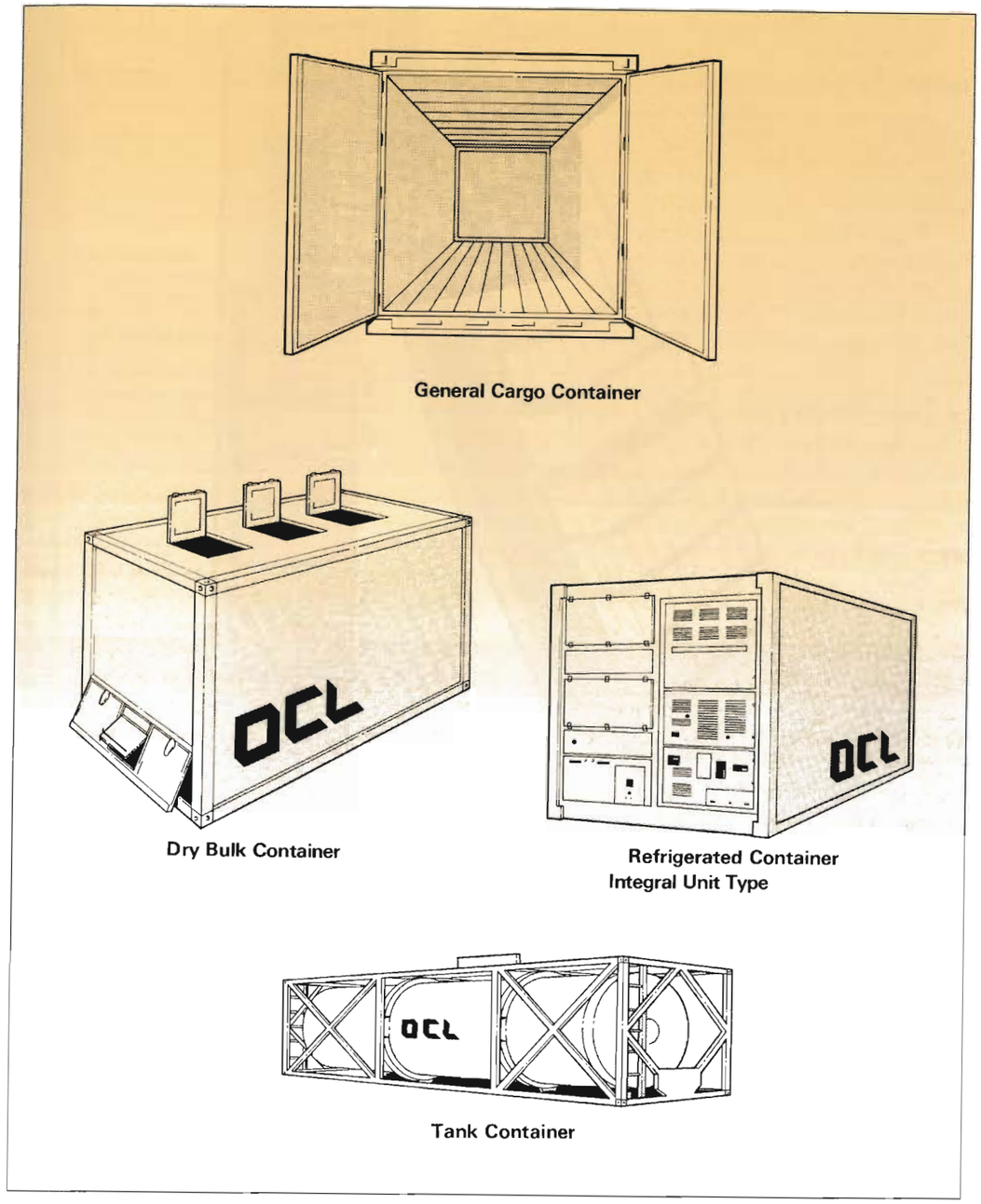


Figure 1.7 Examples of different types of containers.

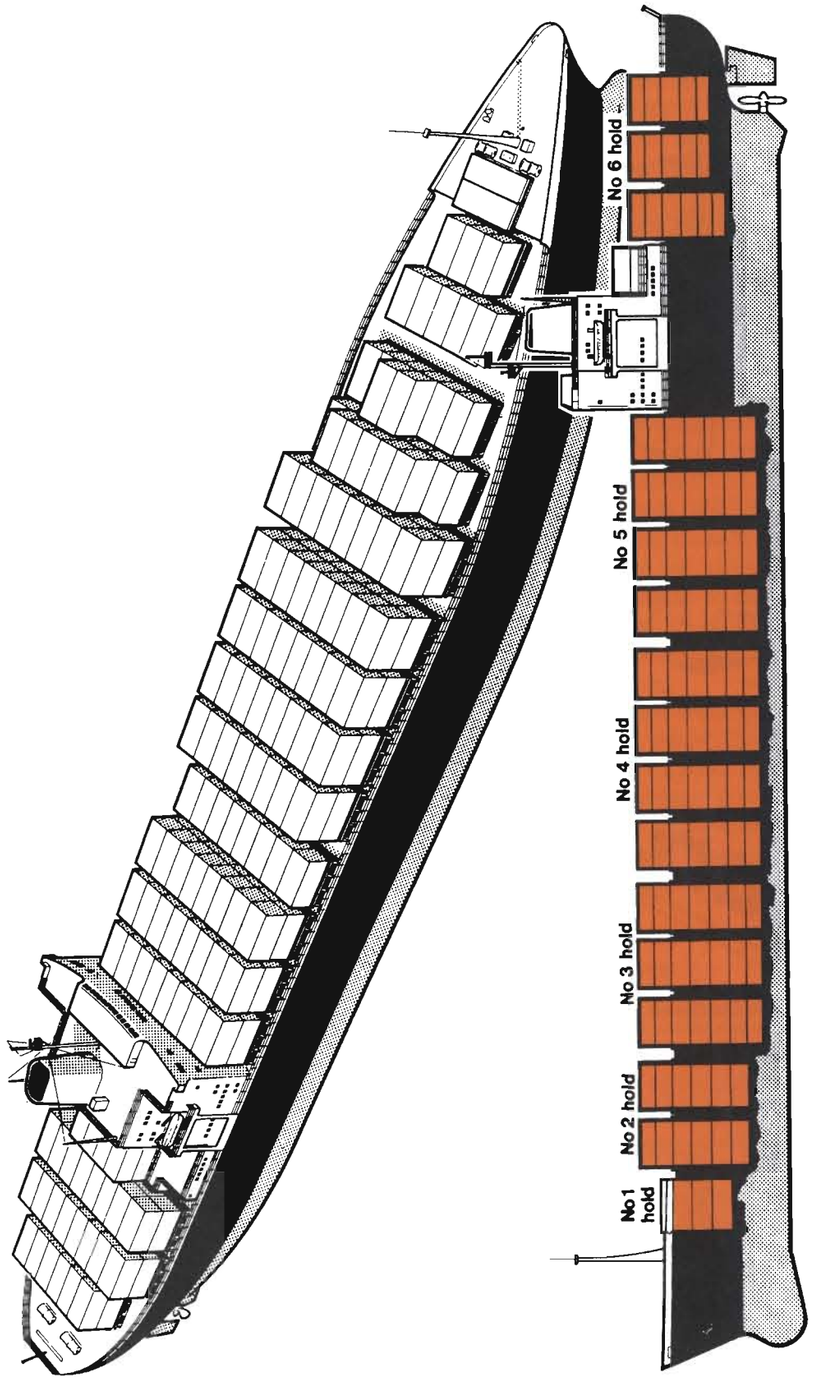
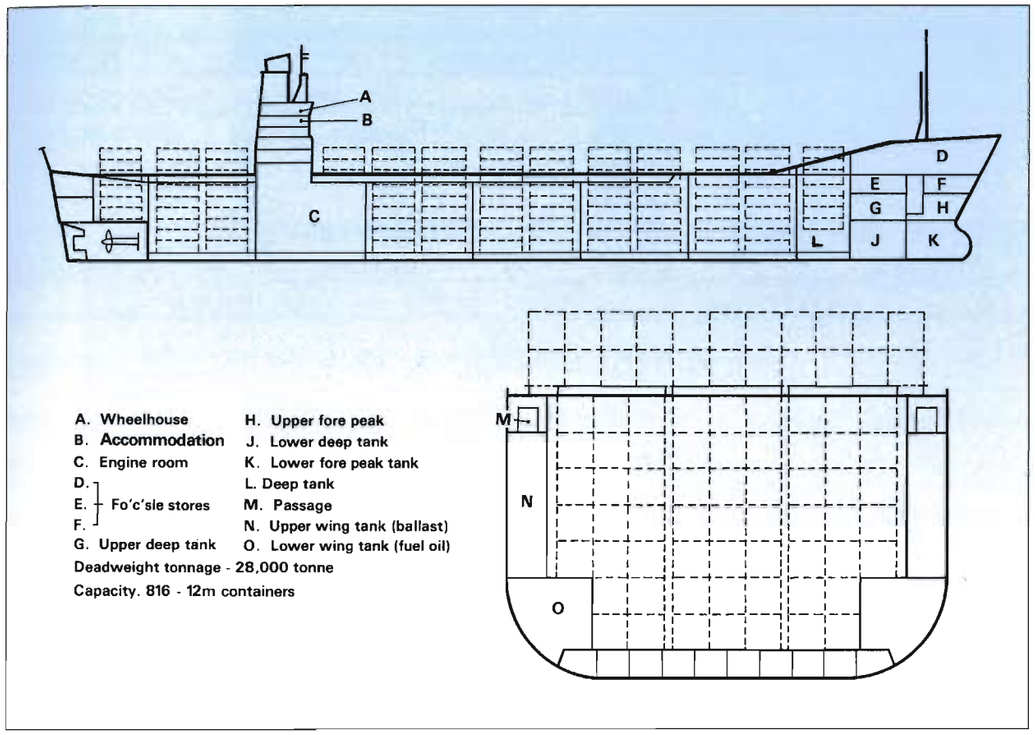


Figure 1.8 One type of container ship showing the general arrangement of holds and container stowage.



A. Wheelhouse
B. Accommodation
C. Engine room
D. E. F. Fo'c'sle stores
G. Upper deep tank
H. Upper fore peak
J. Lower deep tank
K. Lower fore peak tank
L. Deep tank
M. Passage
N. Upper wing tank (ballast)
O. Lower wing tank (fuel oil)

Deadweight tonnage - 28,000 tonne
Capacity. 816 - 12m containers

Figure 1.9 A profile and cross-section of a container ship of 28,00 tonne dwt.

Photo. 1.1 Container ship, also showing dockside facilities. (HMFSI)

Photo. 1.2 Container markings. *(Essex Fire and Rescue Service)*

Photo. 1.3 Container handling. *(Essex Fire and Rescue Service)*

Photo. 1.4 Container ship being loaded. *(Essex Fire and Rescue Service)*

Photo. 1.5 Container handling equipment. (Essex Fire and Rescue Service)

Photo. 1.6 Container tank. (Essex Fire and Rescue Service)

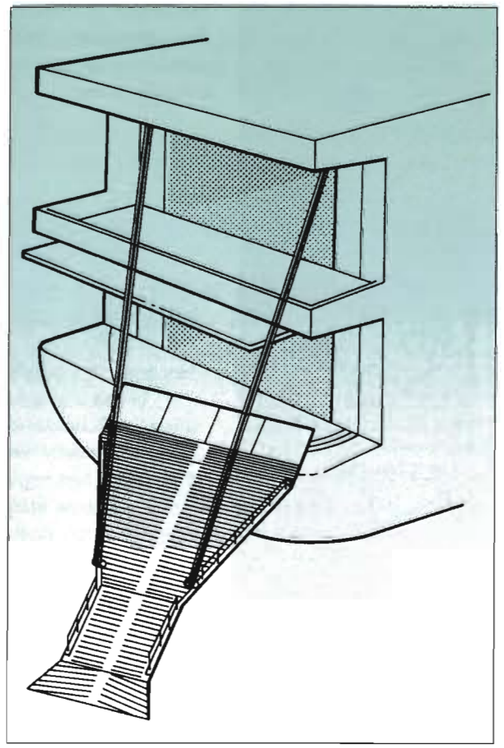


Figure 1.10 Typical skew-ramp for loading vehicles onto a Ro-Ro.

Some container ships are being designed especially for use at ports where there is no conventional handling gear. These have access to cargo spaces through doors in the bow, and carry equipment such as bogies and heavy duty fork-lift trucks for loading and unloading.

1.4 LASH ships and barge-aboard ships

'LASH' stands for 'Lighter-aboard ship'. A lighter is a large floating box into which various goods, often mixed, can be loaded and which is then lifted aboard by crane. Some ships can carry between about 70 and 90 lighters and may have both lighters and ordinary containers on board at the same time.

Barge-aboard ships have three continuous cargo decks, with no hatch openings on the top as loading is carried out horizontally by means of a moving platform at the stern. These ships can carry 12 barges on the lower deck, 12 on the main deck and 14 on the upper.

1.5 Roll-On Roll-Off (RO-RO) Ships (other than passenger car ferries)

These vessels have loading ramps via which vehicles can drive on and off (Figure 1.10). A particular example is the bulk carrier which can transport very large numbers of cars (2000 is not uncommon and some carry very many more) (Figure 1.11 and Photo. 1.7). One important feature is the large number of decks: 12 is typical. As on partial container ships, these decks may be adjustable, i.e. suspended on cables so that they can be raised, lowered or removed to facilitate loading, unloading and the carriage of different cargoes.

A vessel designed to carry general cargo and/or containers, in addition to vehicles, may be referred to as a Sto-Ro ship; this type of ship may still carry a large number of cars. Sto-Ro ships have remotely-controlled watertight doors in the holds, to shut off part of the ship if it springs a leak.

The cars are usually driven onto the ship through bow or stern loading doors and into position via ramps, then secured. The car spaces are like large hangars, with no bulkheads, and headroom is very limited. They usually have mechanical ventilation. Movement across them is very restricted because the cars are very tightly packed together. When the loading doors are closed, main access to the car decks is via stairs in the accommodation section and through sliding doors.

1.6 Insulated Ships

For the carriage of some cargoes, such as foodstuffs, it is necessary to keep the temperature of the hold constant. To achieve this a ship may be insulated wholly (Photo. 1.8) or in one or more holds only; it is not uncommon for an ordinary cargo or passenger ship to have an insulated hold. The material used for insulation varies: it may be non-flammable or it may be a flammable substance such as cork. Sometimes both are used together. The material, fitted between the ship's

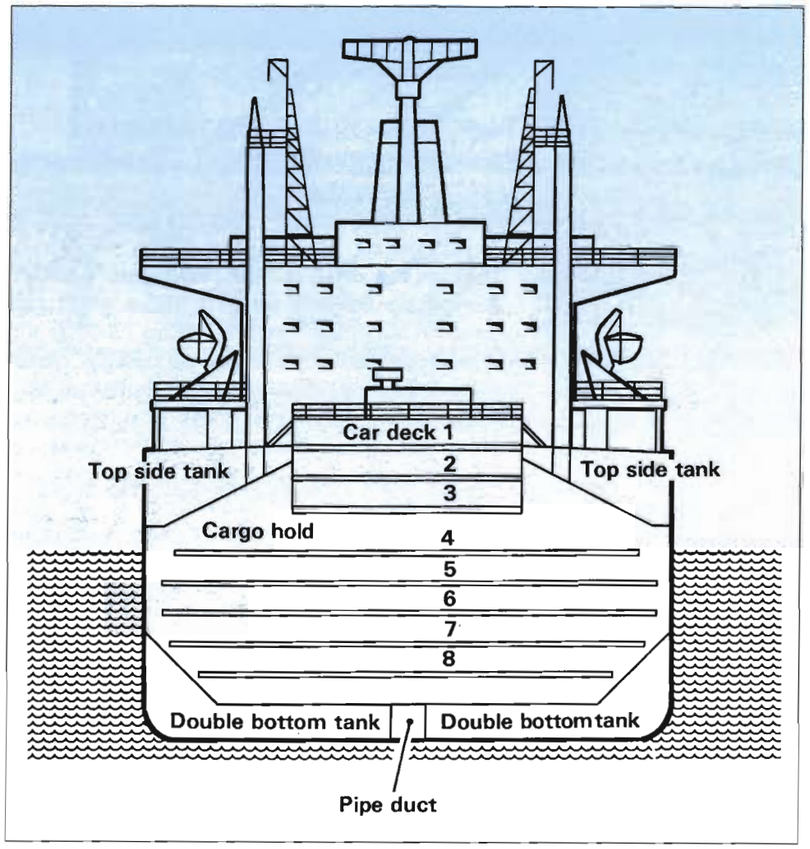
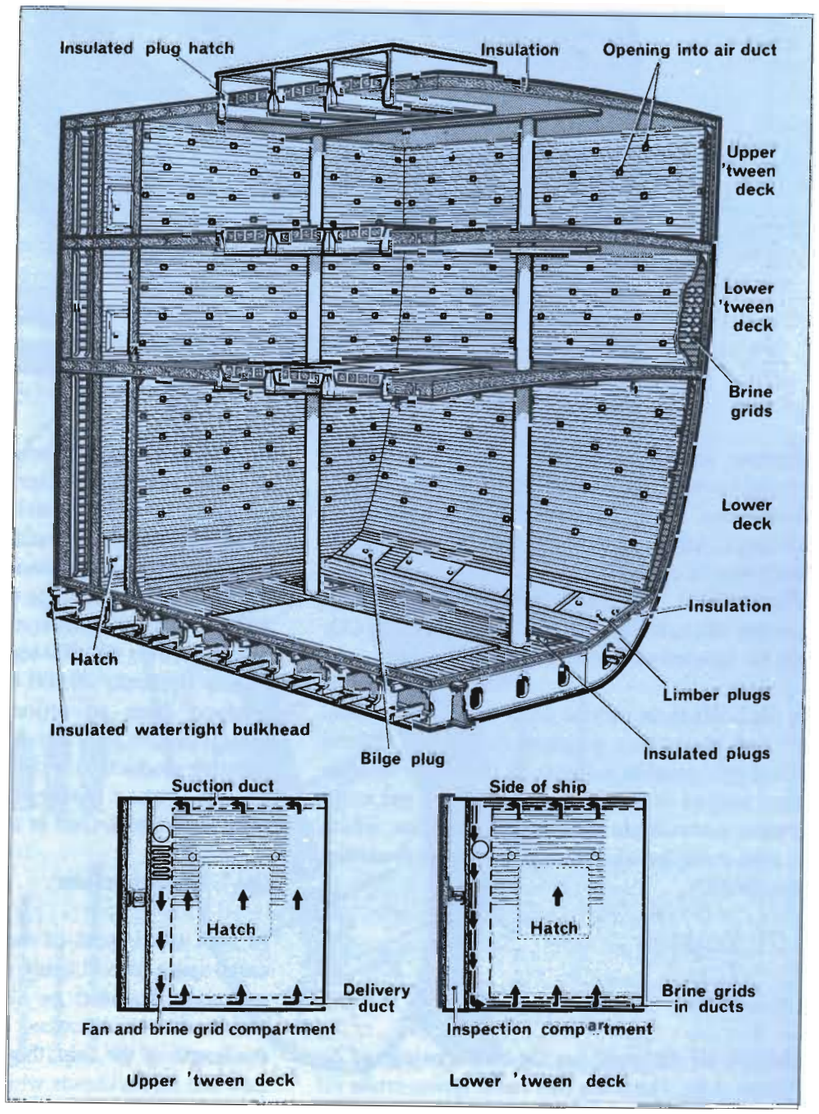


Figure 1.11 Arrangement of portable car decks in a bulk carrier.

Photo. 1.7 Bulk Car Carrier.

Photo. 1.8 Refrigerated ship. *(HMFSI)*

Figure 1.12 Sectional view of a type of insulated ship showing the insulation, brine pipes and plug hatches. Plan sections of two decks are shown below.



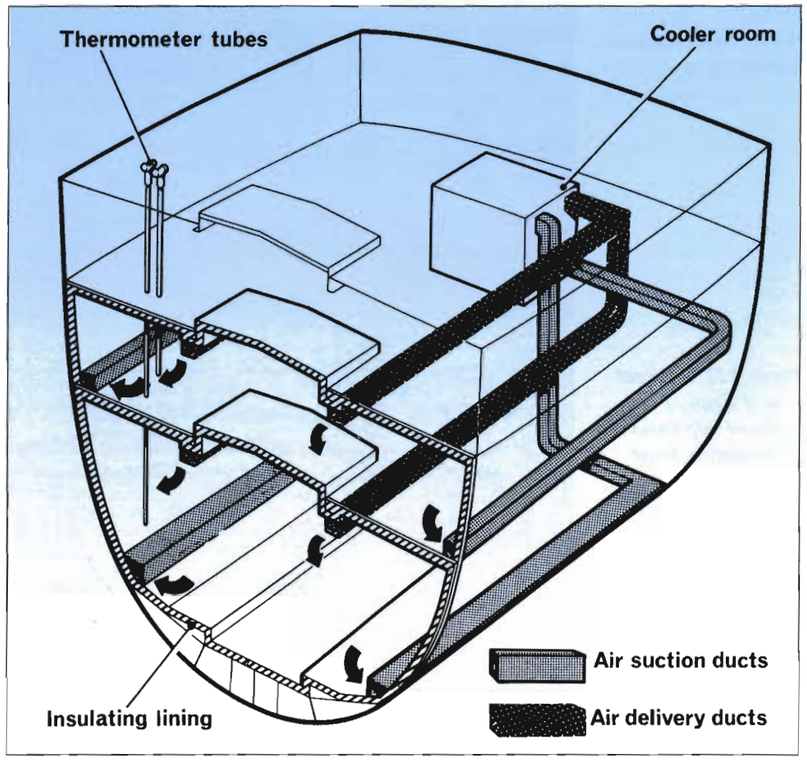


Figure 1.13 Sectional view of the hold of an insulated ship, showing air ducts and thermometer tubes.

structure and an inner lining of wood or metal, wholly envelops each insulated hold (Figure 1.12). Any tween decks within the hold are similarly insulated. After loading has been completed, each hatchway is closed with an insulated plug hatch (Figure 1.12). There are thermometer tubes, one pair per deck, for each hold. Water, steam or CO_2 can be injected via these (Figure 1.13).

In the holds there may be ducts to circulate cooled air and these may penetrate bulkheads. Where actual refrigeration is necessary there may be brine pipes instead of ducts. Gas compression and evaporation methods are used to cool the brine, which in turn cools the air. The gas is usually freon but may be CO_2.

1.7 Tankers

(a) Types

Tankers are designed for the bulk carriage of oil (Photo. 1.9). There are two basic types: crude oil carriers and product carriers. Large tankers are generally used for the carriage of crude oil (crude oil makes up approximately 80% of the oil carried by sea). They are classified by their oil cargo capacity: large crude carriers (LCCs), 100,000–200,000 tonne; very large crude carriers (VLCCs), 200,000–400,000 tonne; ultra large crude carriers (ULCCs), over 400,000 tonne. Product carriers are smaller (typically 20,000 tonne) and carry refined products from oil refineries. There are small coastal tankers, typically 3,000 to 6,000 tonne, distributing products to small ports. There is now also a growing trend to carry clean products (refined) from the Arabian Gulf in 100,000 tonne tankers.

(b) Construction

In both types most of the hull is given over to cargo space, the oil being carried in oil-tight compartments bounded by the hull and transverse bulkheads, which extend about three-quarters of the length of the ship, they are further divided by fore and aft bulkheads which divide the tanks into

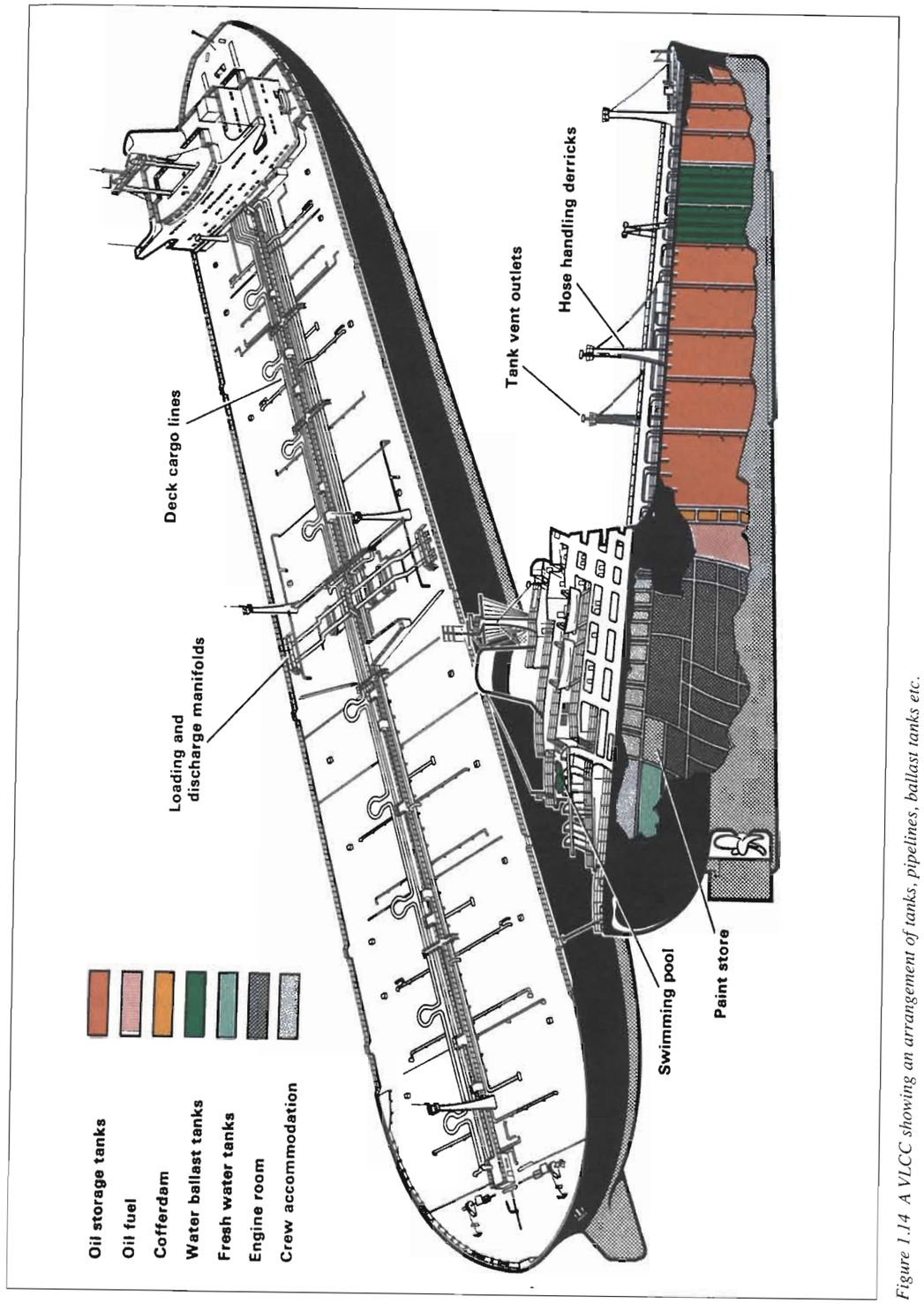


Figure 1.14 A VLCC showing an arrangement of tanks, pipelines, ballast tanks etc.

Photo. 1.9 Product Tanker. (Captain G. Stollery)

two or three across the ship's breadth. This makes the vessels very stable because of the reduction in free surface effect (see Chapter 4). These tanks are separated from the rest of the ship by coffer dams (occasionally by pump rooms and water ballast tanks) (Figure 1.14). The product carriers tend to have more tanks than the crude carriers and with more complicated pipeline systems to allow different grades of cargo to be handled. There are usually no double bottoms under the cargo space, though there are under the machinery space. Newer tankers are being built with double bottoms under the oil tanks to lesson the likelihood of oil pollution after a grounding, although this may introduce new risks in terms of unobserved corrosion, confined spaces that have to be entered and potential explosive atmospheres. Bunker oil may be carried in the machinery space double bottom, and also in a deep tank just aft of the cargo tanks, and in cross-bunker tanks. The superstructure is usually all concentrated at the after end of the ship above the machinery space. It can consist of up to seven decks: the top or 'monkey island' contains the standard magnetic compass, direction finder loop, signal mast, aerials, lights etc.; below this is the bridge, and then accommodation areas, galleys, stores etc.

(c) Loading and discharging of cargo

Oil cargo is loaded and unloaded through large hoses and hard-arms connecting the deck pipelines to shore-lines. Loading is achieved by shore pumps, whilst unloading is done by the ship's pumps. Valves control oil flow on the ship: they may be operated by hand-wheels on the main deck and in the pump room, or alternatively they may be hydraulically powered and/or remotely controlled from a cargo control room. Some large modern vessels have a free flow system of cargo handling, in which the oil is allowed to pass from one tank to another through bulkhead valves; this reduces the amount of pipework needed. Product tankers may have a simple ring main pipeline to handle different grades of oil; alternatively, there may be a central or twin duct system running the full length of the ship. The oil discharged from the tanks is usually replaced simultaneously by inert gas as a fire precaution (Figure 1.15).

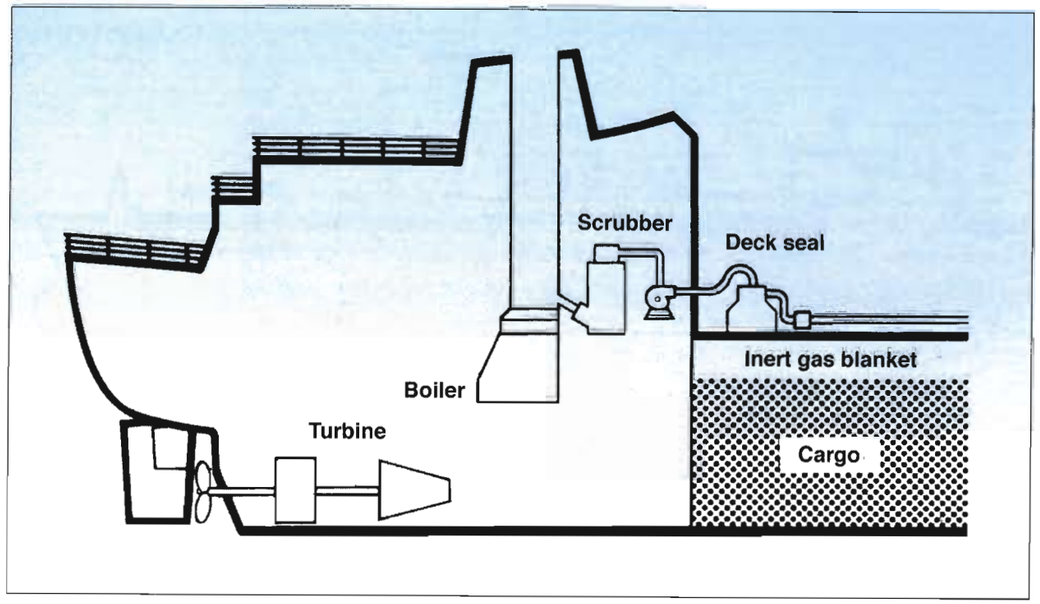


Figure 1.15 Schematic diagram of ship inert gas system.

1.8 Chemical and Gas Carriers

(a) Bulk chemical carriers

The bulk carriage of chemicals is now extensive. Some of the chemicals carried are harmless but others are highly dangerous: they may be easily flammable, with a low ignition temperature; they may also be toxic, corrosive or harmful in some other respect. The construction of chemical carriers must take account of these dangers (Figure 1.16).

Some ships are specifically designed to carry one chemical and are generally quite small. More common, however, are the large parcel tankers which can carry a number of different chemicals at the same time. The International Maritime Organisation (IMO) has drawn up a code of safety provisions to which all chemical carriers should conform. A major provision is that all chemicals, except those in the safest category, must be carried in tanks located away from the sides and bottom of the ship; certain minimum distances are specified for this purpose. There are also requirements on cargo separation. Cargoes which react dangerously with other cargoes should be separated from them by a coffer dam, void space, pump-room, empty tank or mutually compatible cargo. They should have separate pumping and piping systems which, unless encased in a tunnel, should not pass through other tanks containing chemicals that might react; and they should have separate ventilation systems.

The tanks in which the chemicals are carried can be either integral, i.e. forming an essential part of the ship's hull, or independent, i.e. not forming part of the hull structure. In modern ships, the tanks have linings that can be of epoxy, zinc silicate, or stainless steel. The allocation of cargoes to the various tanks will depend not only on the cargoes' compatibility with each other (and with any residue which may be left over from previous cargoes), but also on their compatibility with the tank linings, since these can be damaged by contact with certain chemicals.

All cargo tanks should have an appropriate ventilation system; certain substances require special ventilation arrangements. In some cases it is also necessary to have special controlled atmospheres in cargo tank vapour spaces and in the spaces surrounding the tanks. This can be achieved by:

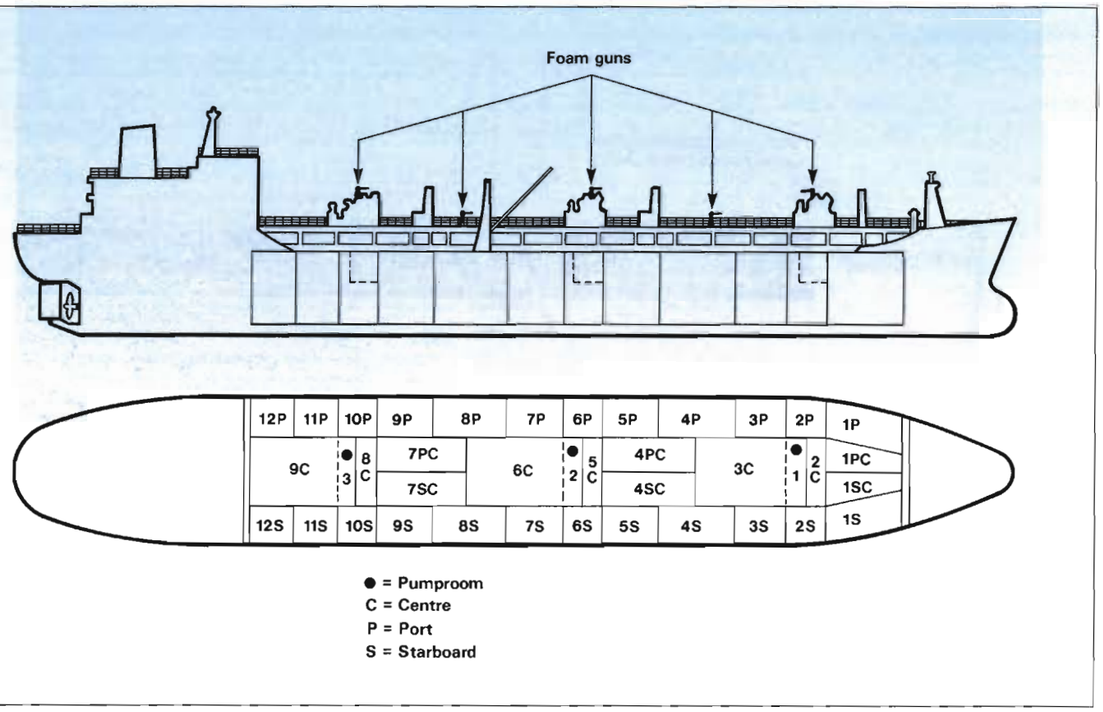


Figure 1.16 Bulk chemical carrier showing tank numbering system.

(i) inerting filling the space with a gas which will not support combustion and which will not react with the cargo (see Chapter 2 – 4 (e));

(ii) padding separating the cargo from the air by means of a liquid or gaseous filling;

(iii) drying keeping the cargo free of water or steam by separating it off with moisture-free gas.

Although some chemical carriers have several pump rooms, an extension of the conventional tanker, the more popular trend is to do away with cargo pump rooms. Each tank would be fitted with a permanent submersible pump which would have its own separate discharge line and manifold which greatly reduces the chance of cargo contamination. Where pump rooms are found they should be so arranged as to ensure unrestricted passage, and access to cargo control valves to permit ease of movement to a person wearing protective equipment. Access ladders should not be vertical, and individual platforms should be fitted with guard rails. The entries to void spaces, cargo tanks and other spaces in the cargo tank area should, likewise, be accessible for a person wearing BA, and there should be direct access to the cargo tanks from the open deck.

(b) Gas carriers

Gas carriers most commonly carry liquefied petroleum gas (LPG) but some carry liquefied natural gas (LNG) or chemical gases such as ammonia. They are normally of an all-aft design but the number, position and form of their tanks vary (Photo. 1.10). They can be (a) integral tanks, forming an essential part of the vessel's hull; (b) membrane tanks, consisting of a thin metal lining (or two linings with insulation between them) supported by the insulating material within the ship's hull; (c) semi-membrane tanks, which stand alone when empty but expand to be supported by

Photo. 1.10
Small Gas Tanker.

the insulation when full; or (d) independent, self-supporting metal tanks with a single or double wall, not forming part of the hull. In shape they may be cylindrical, spherical, or straight-sided, or conform to the contours of the hull, and their location may be in the holds or on the decks, side by side, or on the centre line, or in pairs to port and starboard (Figure 1.17). The vessel may also have topside wing tanks, usually to carry water ballast.

In view of the low boiling point of the liquefied gas, cargoes have to be carried under more than atmospheric pressure, under refrigeration or under a combination of the two (Figures 1.18 and 1.19).

Refrigeration may be as low as -50 degrees C in the case of LPG carriers, and -164 degrees C in LNG carriers. In the latter, the cargo tanks have to be insulated not only to prevent cargo evaporation

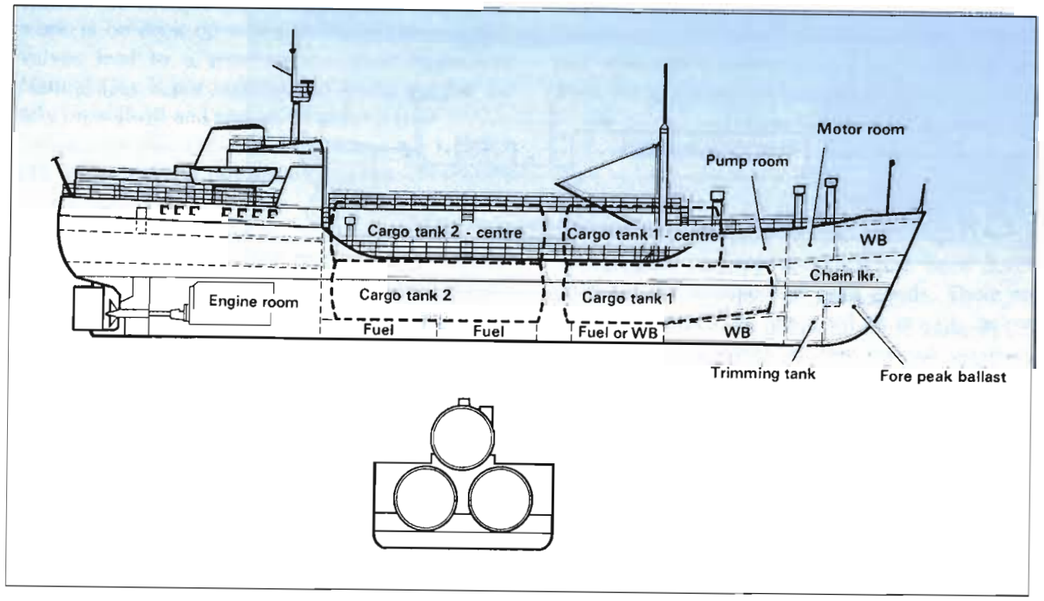


Figure 1.17 General arrangement of LPG carrier.

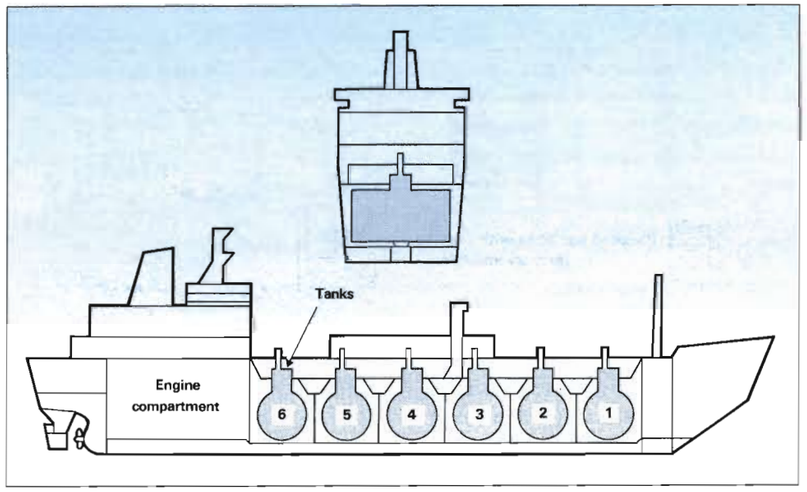


Figure 1.18 4,100 m³ semi-pressurised/fully refrigerated LPG/ Ethylene gas carrier.

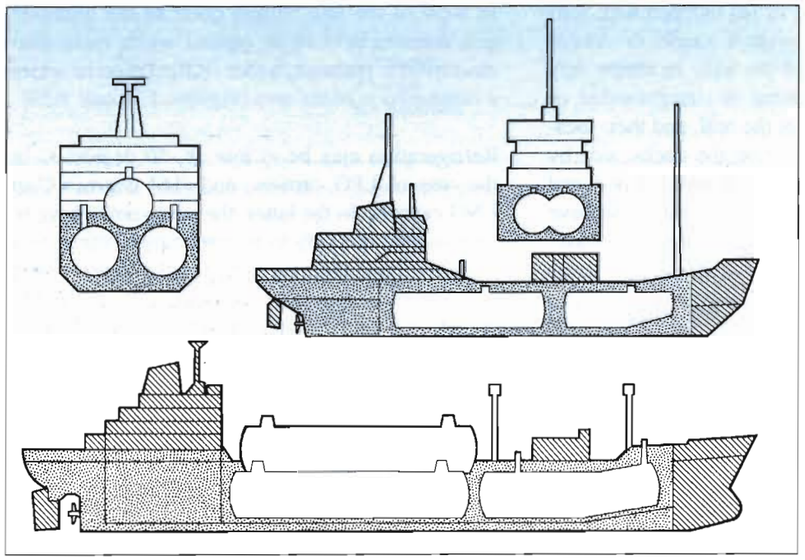


Figure 1.19
TOP:
Pressurised ship, 900 m³ capacity gas carrier.

BELOW:
Semi-pressurised/fully refrigerated LPG/ Ammonia carrier with 12,600 m³ capacity.

and pressure build-up within them but also to protect the rest of the ship's steel structure against low-temperature embrittlement. Balsa, polyurethane foam, perlite and polystyrene foam are some of the materials used for this purpose (Figure 1.20).

These ships are usually equipped with inert gas generators and the large types with fixed and mobile firefighting systems. To cover the tanks and manifolds, remotely controlled dry powder monitors may be installed, plus handlines from mobile Monnex dry powder units. Such vulnerable areas as cargo tank domes, compressor rooms and the front of the superstructure are protected by water-spray systems. CO_2 or other inert gas systems could be found protecting the engine room and generator areas etc.

Only smaller coastal vessels carry fully pressurised cargoes in strong steel tanks, larger vessels will be partially or fully refrigerated, although there may be pressurised vessels on deck. There

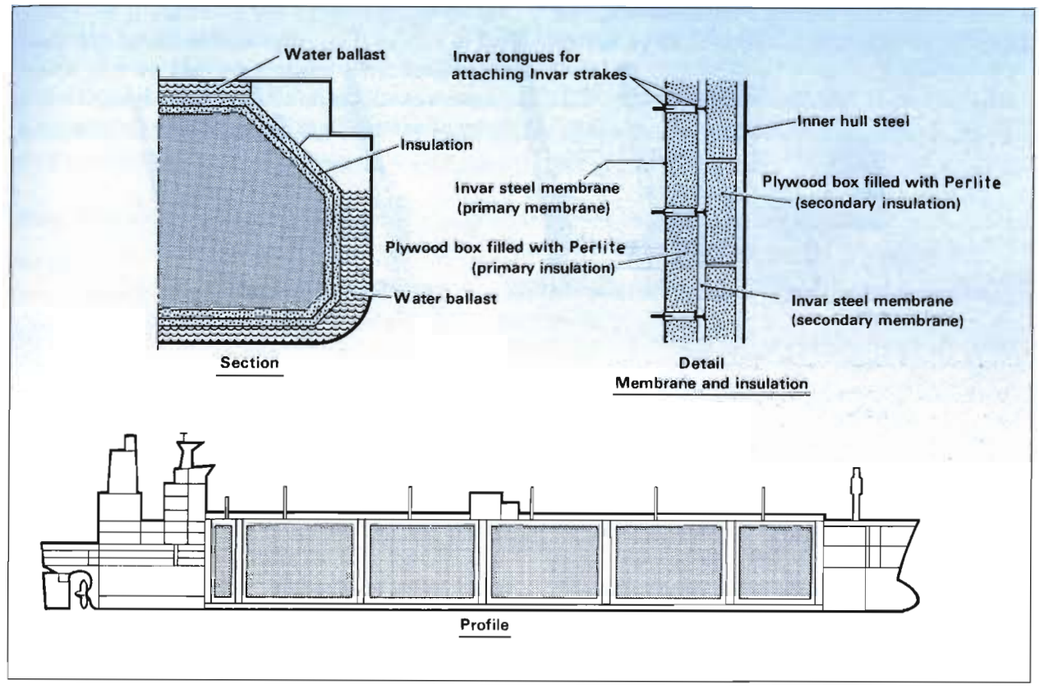


Figure 1.20 Gas transport using membrane tank system, showing type of insulation used around the tank.

will be machinery spaces on the cargo deck associated with re-liquefaction of the cargo. All pipework is on deck on a gas tanker, pressure relief valves lead to a riser up the mast. Liquefied Natural Gas is not liquefied on board and has to rely on boil-off and insulation to keep cold.

(c) Combined chemical/gas vessels

There may be, in the future, an increasing number of ships having features of both types of vessels mentioned above and designed to carry both chemicals and gases either separately or at the same time. Some already in service have very sophisticated cargo systems and can carry a wide range of both commodities. They can accommodate a considerable spread of cargo pressures, specific gravities and temperatures, with facilities for both heating and direct (vapour) or indirect (circulating liquid) cooling and extensive cargo tank insulation. The tanks are few and relatively large with a small number of hatches. Cargo is moved by pumping or by pressurising the tanks with air or nitrogen. Particular problems that might occur with these ships are poor ballast capacity, decreased stability, the absence of a cargo control room and difficulties with safety valves (those for chemicals and those for gases are not interchangeable).

1.9 Bulk Carriers

General cargo vessels are not entirely suitable for carrying bulk cargoes such as grain, ore or coal. Special bulk carriers have therefore been developed for the transport of such goods. There are four main types as described at (a)–(d) below. Those carrying more than one type of cargo are known as combination carriers.

(a) General bulk carriers

These have a large cargo hold volume with large hatches having heavy, watertight steel covers. There should be a substantial ballast capacity (Photo. 1.11).

Photo. 1.11 Bulk Carrier (Ore).

(b) Ore carriers

These carry their cargo in narrow holds, the inner bottoms of which are raised up to 4 metres above the keel. The surrounding spaces, or side tanks, are sub-divided and used to carry water ballast.

(c) Ore and Oil carriers (O/O)

These vessels can carry either oil or ore, but not both together. The holds are raised above the keel, but not as far as on ore carriers. The bulkheads are specially strengthened. Hatch openings are oil-tight. Ore is carried in the centre holds with the wing and ballast tanks empty; oil is carried in the holds and in the wing tanks. The vessel has pipework and pumping systems similar to those of a crude carrier, and there is usually some form of cargo handling gear near the pump house.

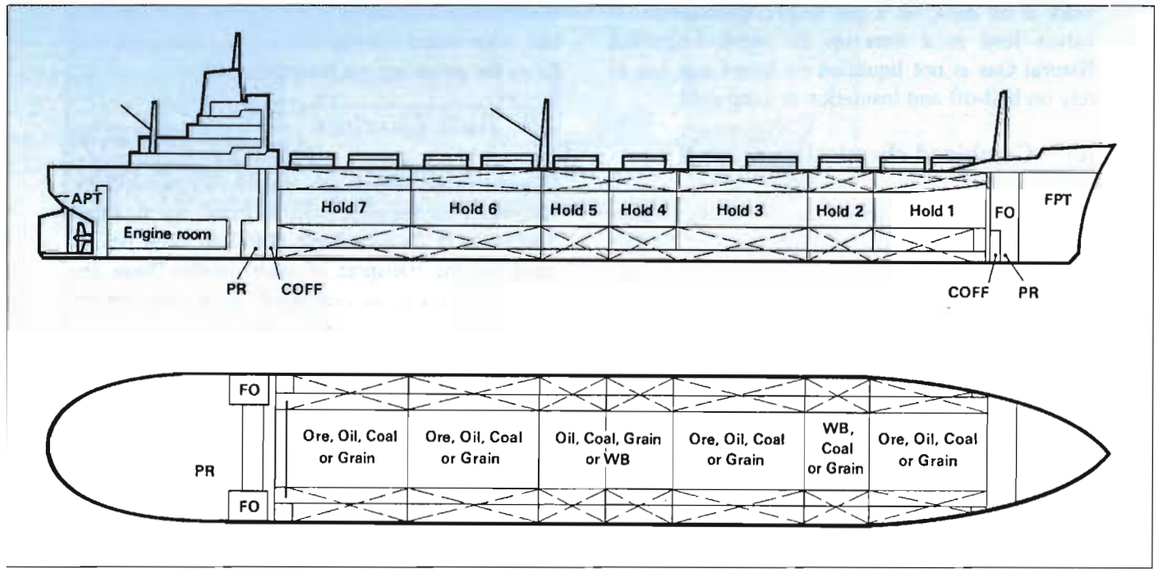


Figure 1.21 A bulk carrier showing lay-out of holds and compartments and a typical division of cargo.

(d) Ore/Bulk/Oil carriers (OBO)

These vessels carry ore, oil or general bulk cargoes (Figure 1.21). The holds, unlike those on the ore and O/O ships, may extend the full width of the ship and are not always raised above the double bottoms. Hatches are small with oil and gas-tight covers. Ore is carried only in alternate holds, but oil in all; there are pumping systems installed to enable this. The double bottoms and upper wing tanks are used for water ballast. On both O/O and OBO ships, coils or ducts for heating the heavy oils are usually located under the tank tops, behind shields at the base of the bulkheads, or under deck-heads to be lowered by winch as required. Some OBO types are known as PROBO ships (Products (oil) Ore, Bulk, Oil).

(e) New developments

Developments of the bulk carrier include the 'geared' carrier for general cargo, phosphate, ore, timber or containers, cargo handling being by means of travelling gantries; and a ship which can be converted from a general bulk carrier to a car carrier by the lowering of a number of car decks.

1.10 Passenger Vessels

(a) Passenger car ferries

These vessels (Figure 1.22 and Photo. 1.12) typically carry 250–500 cars, fewer if larger vehicles are carried. They usually have hydraulically operated doors at bow and stern for vehicles to drive to and from the car decks, and are sometimes included in the category of RO-RO ships. (The non-passenger-carrying type of RO-RO ship is dealt with in Section 1.5 above). Private vehicles may be stowed in two tiers at the sides with large commercial vehicles in the centre, At the after end of the ship is a short partition containing various services. In contrast to bulk car carriers, there is reasonable headroom, and movement between vehicles is not impossible. The main car decks have no bulkheads and are like large hangars, with side mezzanine decks. Access to them when the doors are closed is via stairs and sliding doors from the upper decks. On some ships the top deck, which is open, may be used for commercial vehicles carrying dangerous substances (Chapter 7).

Some dangerous goods are allowed to be carried below decks on these vessels.

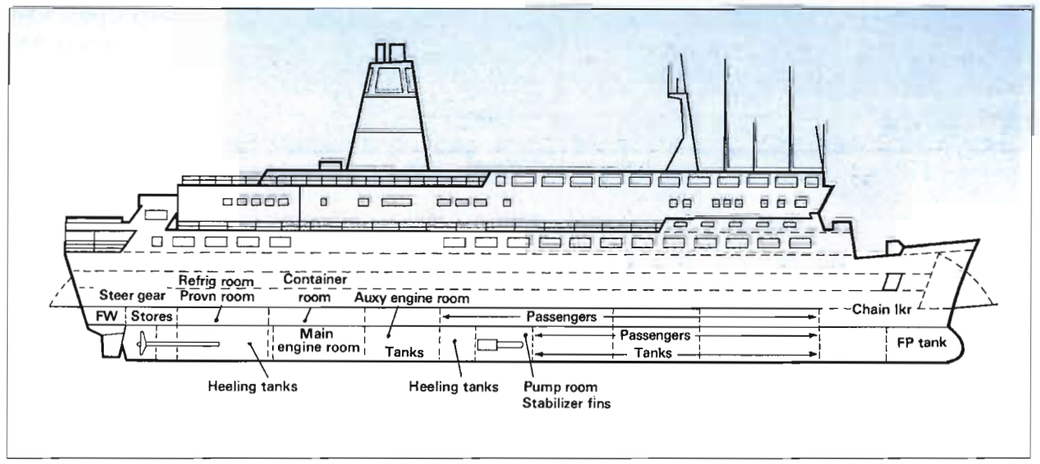


Figure 1.22 Typical car and passenger ferry. There may be two or three car decks plus moveable mezzanine decks.

Photo. 1.12
RORO Ferry (Passenger).
(P & O Stena Line)

There may be first-class cabins at boat deck level; second-class are usually below the car decks, forward of the engine space. Access to cabins is normally via enclosed stairs from the promenade deck. At various levels there will be public facilities such as the restaurants, bars and shops with their associated service areas. There may be as many as 1500 people on board.

The engine space is usually amidships at the lowest level, and the normal access to it is via staircases from the upper decks. Engine rooms sometimes have low deckheads because they are below the lowest car deck. Some vessels, referred to as 'freight ships', are designed to carry heavy goods vehicles only, but as the drivers are passengers these are still classed as passenger vessels (Photo's 1.13 and 1.14). However, if the number of drivers is limited they are allowed to carry goods of a higher degree of danger than would be normal on a passenger ship.

Photo. 1.13
RO-RO Commercial vehicles.

Photo. 1.14
RO-RO Commercial vehicles.

(b) Passenger cruise ships

A large passenger vessel of this sort, used for long journeys and cruises, can have a crew of as many as 1400 to manage the ship and tend to the needs of perhaps 3000 passengers; it may have as many as 14 decks (Photo. 1.15). The one immediately above the water level is the statutory bulkhead deck. Decks should all be numbered from the keel upward and cabins from forward to aft, by requirement of recent amendment to the SOLAS convention, but some marine administrations may not have enforced this requirement for older ships. They may be denoted by letter or names, typically from the main deck down and a sun, boat, games, promenade or other deck above deck 'A', and other unlettered decks below those used by the passengers. Advice should be sought to confirm particular ships. Below the statutory bulkhead deck (known as the 'freeboard deck') the hull is divided by watertight fire-resisting bulkheads, and compartments can be isolated by closing the port and starboard watertight doors located in each bulkhead on each deck. The doors can be operated manually from either side or electrically from a master control on the bridge.

Above the freeboard deck the hull and superstructure are divided by non-watertight fire zone bulkheads with openings closed by fire doors. These

Photo. 1.15
Cruise Ship (Oriana).
(P & O Cruises Ltd.)

doors are normally open, but close automatically in the event of a fire; they can be closed mechanically by the release of a local control.

There are generally passenger cabins down each side of the ship, with a longitudinal corridor inside; either further cabins or service spaces such as ventilation rooms, ventilation shafts, electrical switchboards, passenger service pantries, lift shafts, offices and diesel machinery uptakes.

At intervals along the length of the ship, will be stair towers. These are considered the escape route for passengers and crew, and therefore are fully insulated, as well as being protected by fire doors on each deck.

The public rooms on the ship – showrooms, cinemas, theatres, bars, dining rooms, restaurants (and their adjoining kitchens) – are generally large spaces (Photo. 1.16).

There are also longitudinal working alleyways on some lower decks, which give access to crew accommodation, store rooms, refrigerators, and machinery spaces to allow the efficient movement of stores, spares and crew.

Passenger ships are a high fire risk, with a large amount of passenger rooms and facilities. The overall pattern of rooms, and corridors can be very complex. Decorations, furnishings and fittings are generally elaborate and in older ships may be flammable. Panelling and false ceilings create air space, which can promote fire spread, though regulations require the fitting of draft stops above these ceilings, and the fitting of smoke or heat detectors in these spaces. It is also in these spaces that the cabling and pipework will be carried.

The principal fire risk areas on a passenger ship are the machinery spaces, the laundry, and galleys (kitchens) crew and passenger. Conduction of heat by the steel or aluminium structure can assist the spread of fire. Current regulations require fire alarms and detection systems throughout the ship together with sprinklers at deckhead level

(c) High Speed Craft (HSC) – Passenger

This type of vessel varies in size from craft capable of carrying a few hundred passengers to others with capacity for 1500 passengers and 400 cars or a mixture of cars and large commercial vehicles, dangerous cargoes are unlikely to be encountered. Typically HSC are constructed from either aluminium or a thin high tensile steel hull with aluminium superstructure; being of either a mono or twin hulled form; mono hulls may also be fitted with some form of hydrofoil.

Photo 1.16
Public room on Cruise ship (Oriana).
(P & O Cruises Ltd.)

Photo. 1.17
High Speed passenger vessel overtaking a conventional vehicle/ passenger ferry.

The public areas are situated on one or two decks and are typically of an open style. Cabin space for passengers and crew is very limited on current vessels but future ships may well have more extensive passenger facilities.

HSCs are typically operated on the lines of an aircraft with a relatively small crew (Photo. 1.17).

The firefighting philosophy on HSC is to fit sophisticated detection and extinguishing systems together with the use of fire retardant insulation throughout; some smaller HSC on specific restricted routes may not be equipped with such high tech provisions. HSC are provided with rapid evacuation methods not dissimilar to aircraft.

(d) Hovercraft

Hovercraft were a British invention and they are now used throughout the world. They ride on a cushion of air which is surrounded by a flexible rubber skirt and this allows them to travel with the minimum resistance over many different surfaces. As well as being used for passenger and vehicle ferries they are also used for military and coastguard duties for utility purposes and for flood or air crash rescue.

Light hovercraft, weighing less than one tonne unladen, are not restricted in the UK. All hovercraft being used for hire or reward are subject to operational restrictions.

As well as the amphibious types which can operate over land, water, ice or snow, there are non-amphibious sidewall or SES types which are similar to catamarans.

Hovercraft are usually built of aluminium alloy or composite materials which, although they are fire retardant, are ultimately combustible.

Light hovercraft are permitted to use petrol engines, whereas all other hovercraft must use diesel or kerosene fuel. An example is the cross-channel hovercraft running between Dover and Calais which uses four gas turbine engines whilst others use up to four diesels. Each engine compartment must have its own automatic extinguishing system.

Hovercraft are built on multi-compartment hulls so that in the event of collision in which the hull sustains damage, it should remain floating. The light superstructure may also sustain damage.

In the event of a hovercraft capsizing (this occurred on one occasion) there is a breakthrough zone marked on the underside of the hull. However, it is now thought unlikely that modern hovercraft will ever capsize.

Should a hovercraft break down they are difficult to tow as their skirts act as sea anchors but they can be towed slowly. Liferafts and lifejackets have to be carried for use in any of the emergencies mentioned.

1.11 H. M. Ships

Naval vessels differ in design according to their function: aircraft carrier, frigate, destroyer, minesweeper etc. (Photo's 1.18, 1.19 and 1.20). All are very much more extensively divided into watertight compartments than comparable merchant ships, the divisions being both transverse and longitudinal. All decks below a point about 2.5 metres above the exterior water level are fitted with watertight doors and hatches to help prevent, primarily, the spread of floodwater but also the spread of smoke. The ventilation systems in warships are quite extensive and invariably breach

Photo. 1.18 Aircraft Carrier (HMS Ark Royal)
(British Crown Copyright/MOD. Reproduced with the permission of Her Majesty's Stationery Office.)

Photo. 1.19 Frigate (HMS Monmouth)
(British Crown Copyright/MOD. Reproduced with the permission of Her Majesty's Stationery Office.)

Photo. 1.20 Nuclear Powered Submarine (HMS Vanguard)
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watertight decks and less commonly, bulkheads. Although protected by watertight/gas-tight valves, these valves are often difficult to operate in an emergency; therefore, the potential for fast smoke spread must not be overlooked. All ships have the facility to crash stop their vent fans in a matter of seconds from the Ship Control Centre (SCC). The extensive use of alloys and modern techniques makes possible considerable addition to the superstructure. Electrical and mechanical systems are very complex and naval vessels are generally more comprehensively equipped with portable and fixed firefighting apparatus than their merchant navy counterparts. Apart from magazines and weapons storage areas, they are also likely to have less flammable material aboard. A unique system for the identification of compartments in RN warships is briefly described below:

Basically, decks divide the ship horizontally from the weather deck to the inner bottom including the superstructure. Main transverse bulkheads divide the ship lengthwise into main sections. Minor transverse bulkheads further divide these main sections. Longitudinal (fore and aft) bulkheads – many in large ships, few in small ships – also divide the main sections. For convenience, a main transverse bulkhead (and hence a main section) is assumed to continue upwards to the top of the structure even though it may actually finish at a lower deck. Similarly, deck levels are in most cases assumed to be continuous through the ship.

The identification of doors, hatches, manholes throughout the ship are indicated by an alpha/numerical notation by the location of the compartment in which they are situated, or to which they give access.

- Vertical component (deck level) – indicated by a large NUMBER showing the deck on which the compartment is situated (Figure 1.23).
- Fore and aft components – a large capital LETTER indicates the main transverse subdivision.
- if needed, a SUFFIX LETTER (SMALL CAPITAL) indicates its position, forward or aft, within the main transverse subdivision. (Figure 1.24)
- If needed, an athwartships component – a small NUMBER indicates the athwartship position in relation to the centre line of the ship.

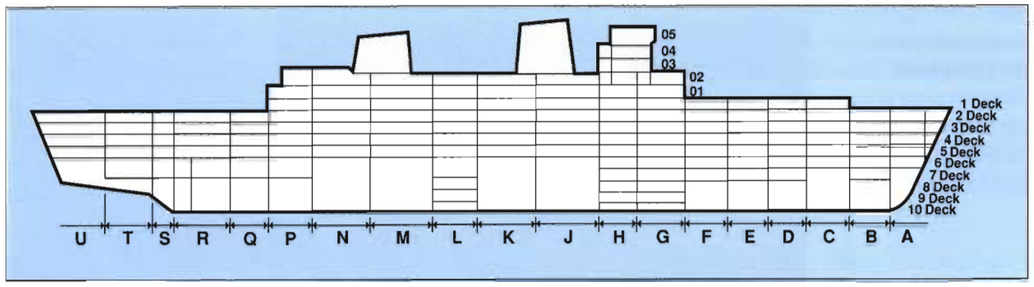


Figure 1.23 Decks and main sections.

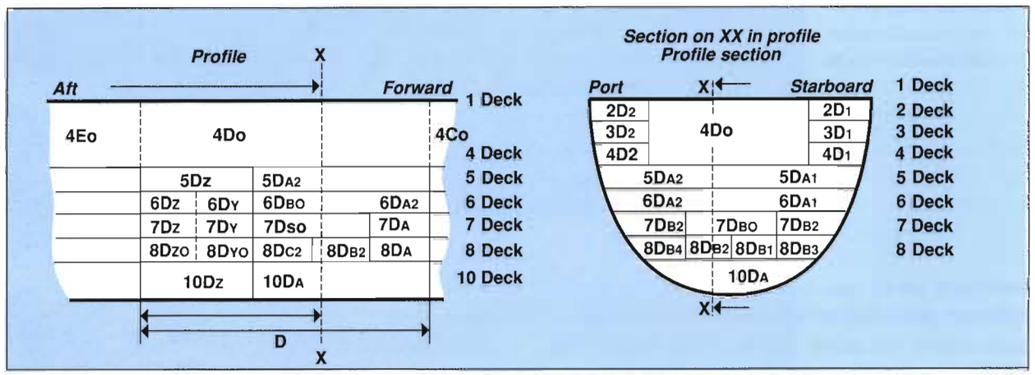


Figure 1.24 Compartments.

Decks are numbered consecutively downward to the outer bottom, starting with the forecastle deck as No. 1 deck. In aircraft carriers, No. 1 deck is the flight deck. Decks above No. 1 deck are numbered 01, 02 and so on, consecutively upwards.

The main sections and subdivisions formed by the transverse watertight bulkheads are lettered A, B, C, and so on, from forward to aft. The letters I and O are omitted to avoid confusion with deck numbers.

Watertight compartments formed by transverse bulkheads within these main sections are given suffixes, A, B, or C starting from forward, or Z, Y or X, starting from aft, as well as the marking of the main section. In the case of an odd number of watertight compartments within a main section, precedence in the suffix letters is given to the top end of the alphabet, e.g. ABC YZ; AB Z; ABCD XYZ.

Note. *These suffix letters are capitals, but smaller than the main section letters and deck figures, as indicated in Figure 1.24.*

The subdivision of a main section into watertight compartments athwartship are indicated by small numbers used after the deck number and section letter or letters: Odd numbers indicate compartments to starboard of the centre line of the ship and even numbers indicate compartments to the port of the centre line of the ship. In each case the numbering is outwards from the centre line. Compartments on the centre line are thus numbered '0'. (Figure 1.24)

Chapter 2 – Ship-Board Fire Protection

2.1 Legislation

The Safety of Life at Sea (SOLAS) Convention is an international agreement drawn up under the auspices of the International Maritime Organisation (IMO) and updated at intervals. The Convention lays down various standards relating to ship-board fire protection. It is initially at the discretion of individual member states to enforce these standards, as far as their own ships are concerned, by introducing relevant national legislation. After consultation and agreement between individual member states, a standard subsequently becomes mandatory for the shipping of them all. National legislation then becomes compulsory. Voluntary compliance with SOLAS requirements by shipping owners and others in advance of legislation is, of course, always possible.

UK law has already given effect to a number of current or earlier SOLAS requirements as through various Statutory Instruments, which lay down rules concerning ship construction, life saving appliances, firefighting equipment, means of escape etc. Current legislation includes:

1998 No. 1012 Merchant Shipping (Fire Protection: Large Ships) Regulations 1998.

1998 No. 1011 Merchant Shipping (Fire Protection: Small Ships) Regulations 1998.

The schedules (detail) for these regulations are contained in merchant shipping notices:

MSN 1665 (M) Fire fighting equipment.

MSN 1666 (M) Fixed fire detection alarm and extinguishing systems.

MSN 1667 (M) Passenger ships: fire integrity of bulkheads, decks and ventilation ducts.

MSN 1668 (M) Fire integrity of bulkheads, decks and ventilation ducts.

MSN 1669 (M) Special fire safety measures for ships carrying dangerous goods.

MSN 1670 (M) Exemptions.

Further details to be found in 'Instructions for the Guidance of Surveyors – Fire Protection'.

Although foreign ships may comply with the SOLAS requirements, the rules themselves apply only to UK-registered ships. For these the rules represent the legal minimum provision. Some ships may go further; they may, for example, comply with later SOLAS requirements. (these mostly just update the earlier ones and make them more specific).

2.2 Requirements

The exact provisions of the rules relating to fire protection are very detailed and vary according to the class and size of ship. The rules do not apply to vessels of very low tonnage.

(a) Passenger ships

The following are among the more important general requirements. (These are minimum only, and higher demands may be made on large or specialised ships.)

- There should be a fire patrol system, manual alarms throughout the passenger and crew spaces for the patrol use, and a fire detection system in areas which the patrol cannot reach. There should also be automatic fire alarm and detection systems in all accommodation and service spaces, with certain exceptions where there is no substantial fire risk or where there is a smothering gas or similar installation. The systems should give both an audible and a visible alarm. The indicators may be on the navigation bridge, at stations having communication with the bridge, or distributed throughout the ship. They must show the location of the fire which has activated the system.

- There should be a facility for directing at least two jets of water into any passenger or crew space while the ship is under way, and into any cargo space or storeroom.

- The ship should have not fewer than two fire pumps, 3 if over 4000 tonnes and there should be provision to ensure that a fire in any one compartment cannot put all pumps out of action. There should be hydrants in all designated spaces. The system should function when all watertight and bulkhead doors are closed.

- There should be portable extinguishers in all service, accommodation and control spaces.

- If the ship is 1,000 tonne or over, it should have a fixed fire smothering installation (gas or steam) to protect certain spaces.

- Machinery spaces should have special fire protection (water spray, smothering gas or foam installation, foam or other portable extinguishers, sand) according to the type of machinery. When oil can drain from the boiler room to the engine room they must be treated as a single space.

- A minimum of two firefighters' outfits (smoke helmet/mask or BA, safety lamp, axe), plus 2 per 80 metre length of passenger spaces, should be carried, in widely separated locations. At least two should include BA fitted with air hose.

- The ship must carry an international shore connection able to be fitted to its port or starboard side.

(b) Cargo ships

Cargo ships, again according to size, should meet requirements similar to the above, as follows:

- It should be possible for at least two jets of water to reach any accessible part of the ship when it is under way, and any storeroom or cargo space.

- The ship should have at least two main fire pumps and, if necessary, an emergency pump to ensure that a fire in one space cannot render all pumps inoperable.

- There should be portable extinguishers in all service and accommodation spaces (with a minimum of three).

- In some cases there should be a fixed fire smothering installation (gas, steam or foam according to circumstances) to protect the cargo spaces.

- Machinery spaces should have special fire protection similar to that in passenger ships' machinery spaces.

- The ship must carry at least two firefighter's outfits, these being kept in widely separated spaces. Each must include BA.

- If the ship is 1,000 tonne or over, it must have an international shore connection able to be fitted to either side.

(c) Large tankers and combination carriers

The Merchant Shipping (Fire Protection: Large Ships) Regulations 1998 lay down special requirements for large tankers and combination carriers (O/O and OBO ships etc.). These relate mainly to the following facilities:

- Location and separation of spaces.
- Structure
- Fire integrity of bulkheads and decks.
- Venting, purging, gas-freeing and ventilation.
- Fixed deck foam system.
- Inert gas system.
- Cargo pump rooms, fixed fire extinguishing systems.

The Regulations specify certain requirements that these facilities must meet.

In addition to the numerous portable fire extinguishers and water hydrants, there will be a system of foam generation with monitors covering the tops of the tanks. There may also be fixed water-spray protection on the front of the accommodation block, which will have passive protection, and fixed fire protection of the pump room and machinery spaces

2.3 Fire Detection and Alarm Systems

The systems can be of various types. Their layout will be adapted to suit the needs of each particular ship.

Fire detection systems are fitted in accordance with the current Firefighting Rules for passenger and cargo ships. Such systems are particularly important on passenger ships and those sailing with unmanned engine rooms. Fire detection systems will be fitted with audible and visual warnings with indication as to the area affected shown on an annunciator panel which will usually be located on the navigation bridge with an additional panel elsewhere. The actual detector heads may be either heat or smoke detectors depending on the risk area being covered.

2.4 Fixed Fire Protection

Firefighters attending ship fires will find various installations on board. These will vary according to the medium they are designed to handle. They will often have instructions for their use displayed on them; in some cases this is compulsory. It is probably only rarely that firefighters will operate such systems themselves: either the systems will already be in operation when firefighters arrive, or if ship's crew members are unavailable to operate the systems, it may be better for the brigade to use its own equipment. However, a basic knowledge of the systems to be found will be helpful. This is particularly so in machinery spaces where the majority of ship fires occur. Firefighters must not, however, assume that ship-board installations will actually be available or have the desired effect when operated, especially in some foreign vessels.

(a) Steam

Steam is no longer recommended for ships because of changes in propulsion and boiler design, the right sort of steam (low pressure) is no longer available. **However, in case it is met on a very old vessel the following notes are retained.**

On some ships, steam is available continuously and in large quantities, provided that there is sufficient fresh water available and that the machinery spaces have not been affected by fire. The steam must be generated from fresh water since marine boilers cannot normally use salt water. It helps fight a fire by displacing the oxygen from the air and by slowly saturating the cargo as its moisture content condenses. There are, however, disadvantages associated with its use:

- Very large quantities are necessary, especially at first when much is likely to condense.

- It cannot be used on cargoes on which water could not be used, since it would have the same effects, e.g., it may produce dangerous gases or cause certain cargoes to swell. Explosives may be rendered unstable by steam.

- If steam is used intermittently and not consistently, a vacuum may result; this will give rise to a rush of air which could worsen the situation. Air may also be sucked in during earlier stages of the operation when the steam is being condensed to water.

- Steam will cause almost as much damage to cargoes etc., as water.

- Firefighters are unlikely to use steam themselves, but the officer-in-charge may in certain circumstances ask the ship's Master to arrange for this to be done.

(b) Water

Ships are fitted with pumps and fire mains to meet the requirements as laid down in SOLAS. Provided throughout the length of the fire mains are hydrants where one can connect the ships fire hoses and so direct water onto the area affected by fire. The fire mains on deck may in the Merchant Navy be known as 'wash deck pipes' and used for such purposes. The mains are fitted with deliveries from which water can be supplied via hose-lines to the holds and other parts of the ship. On British ships the outlets are standard size female instantaneous coupling but on foreign ships they may vary. All ships of 1,000 tonne or over, however, should carry an international shore connection. This should enable water from a fire tug, or the land, to be supplied to the ship's fire mains, whatever the type of coupling. There has been a trend in recent years to move towards 50mm diameter fittings or even 38mm connections, the reason behind this thinking is that a fully charged 64mm hose is very difficult to handle (Photo's 2.1 and 2.2).

Apart from the normal equipment for delivering water in spray, fog or jet form, firefighters may find certain special items of use. The most significant of these are basement spray, the revolving nozzle, the cellar pipe and the elbow-fog-nozzle. These are described in the Manual, Book 2, Part 2.

Ships may also have a permanently charged automatic sprinkler installation in accommodation and service spaces. In some cases this is compulsory. The installation includes a pressure tank containing a standing supply of fresh water, and a pump drawing sea water which comes into operation automatically when the pressure tank is partially exhausted. On the bridge, and/or elsewhere, there should be some means of indicating which sprinklers are operating. The ship may have fire main inlets fore and aft to which firefighters, in dockside incidents, can connect their appliances so as to pump water from the shore directly into the sprinkler system. Firefighters should make the same use

Photo. 2.1 Small hose connection.

Photo. 2.2 Small hose and branch which may be found on some ships.

of the ship sprinkler system as they would of a land system.

In addition, some ships are fitted with high pressure water fog systems designed to extinguish fire by flame inhibition, cool surfaces and emulsify any spilt oil.

(c) Carbon dioxide

Carbon dioxide, as already noted, is usually supplied from a battery of cylinders in a dedicated CO_2 room, from where it is hard piped to the area to be protected. It may be activated from the CO_2 room or from at least one other position well separated from the other actuation point. It is injected into the protected area through nozzles fitted under the deck (Figure 2.1). There are control valves on the different pipes leading to nozzles and these carry an indication of which compartment they feed. There is often an installation dealing primarily with fires under boiler room floor plates where oil fuel is employed. An audible warning should sound when the gas is about to be released into any working space. Should the vessel be in port and the CO_2 released into the protected space, additional gas may be available via road tankers.

(d) Foam

The fixed deck foam system (or acceptable equivalent) prescribed for large tankers and combination carriers (see above), and also found on some other vessels, e.g. chemical carriers, should have its main control station in a readily accessible area outside the protected zone and be able to deliver foam over the whole cargo tanks area and into any tank or hold of which the deck has ruptured. The system should include monitors and hand-held applicators, plus valves, forward of every monitor position, to close off damaged sections of the foam and fire mains. It should be possible to use the minimum prescribed number of water jets from the fire main at the same time as the deck foam system is in operation. Foam installations will also be found in machinery spaces on some older ships, and in the cargo spaces on certain RO-RO vessels. They have a permanent distribution system of piping and valves or cocks leading to fixed discharge outlets which can, in a few minutes, cover with foam the whole area involved. The installations may also include fixed and mobile sprayers. The systems take different forms, as set out below. Their layout and capacity vary from ship to ship.

- **Pump-operated type**

This has a foam concentrate tank outside the machinery space. Adjacent to it there is an inductor to which leads a dual water supply from the ship's pumps (this should ensure operation if one supply fails). The water passes through the inductor, which adds to it the correct amount of foam concentrate from the tank and delivers the solution to the foam generators in the boiler room. When there are two machinery spaces, the system may include distribution piping, with valves, to discharge the foam to either space (Figure 2.2).

- **Self-contained pressure type**

This type is generally used where suitable pumps are not available on board. Its basic components are a water storage tank and a foam concentrate storage tank. The release of gas from carbon dioxide cylinders expels water out of the one tank and through an inductor, which draws into the stream concentrate from the other tank and delivers the solution to the foam generators. Again, the foam produced then passes from there to the spreaders, via distribution piping if necessary (Figure 2.3).

- **Pre-mixed type**

This system has a large tank containing foam solution. In the event of a fire, carbon dioxide is released into this tank from an attached cylinder or cylinders and drives the foam solution up a tube and along a pipe, to the foam generators, from where the foam is conveyed to spreaders. (Figure 2.4)

- **High expansion foam**

High expansion (Hi-Ex) foam (where provided) will generally be found as a fixed installation which will provide protection to an internal space, this could be an engine room or other machinery spaces, cargo pump room, cargo hold or accommodation. Hi-Ex Foam has the advantage of using a very limited amount of water and generally will not damage machinery or internals within a cargo hold or accommodation block. A further advantage is that the medium will not create a stability problem associated with large quantities of water.

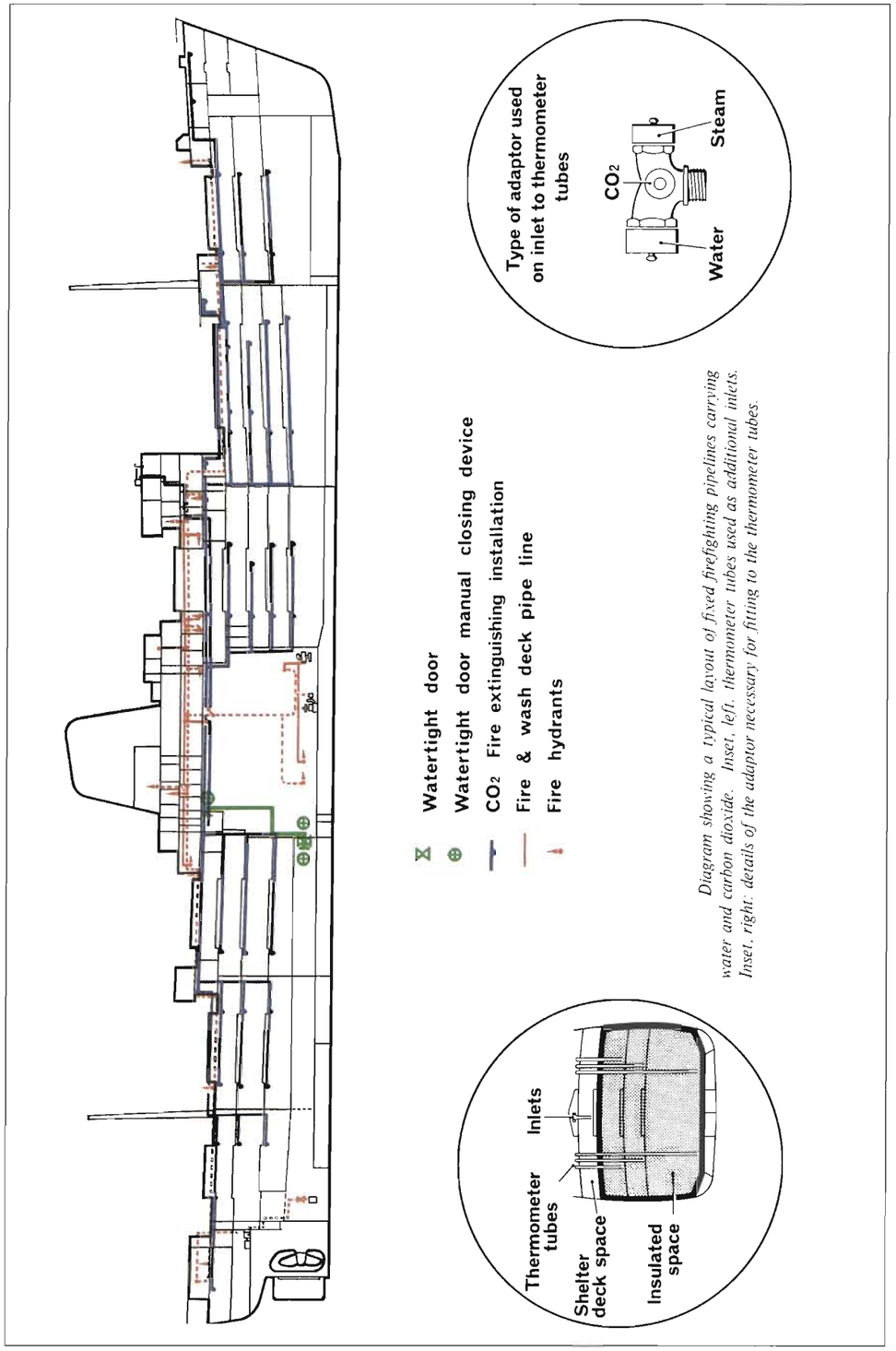


Diagram showing a typical layout of fixed firefighting pipelines carrying water and carbon dioxide. Inset, left, thermometer tubes used as additional inlets. Inset, right: details of the adaptor necessary for fitting to the thermometer tubes.

Figure 2.1 Diagram of a type of fixed firefighting system carrying water and CO_2. Inset left: Thermometer tubes which can be used as additional inlets. Inset right: An adaptor for fitting to a thermometer tube.

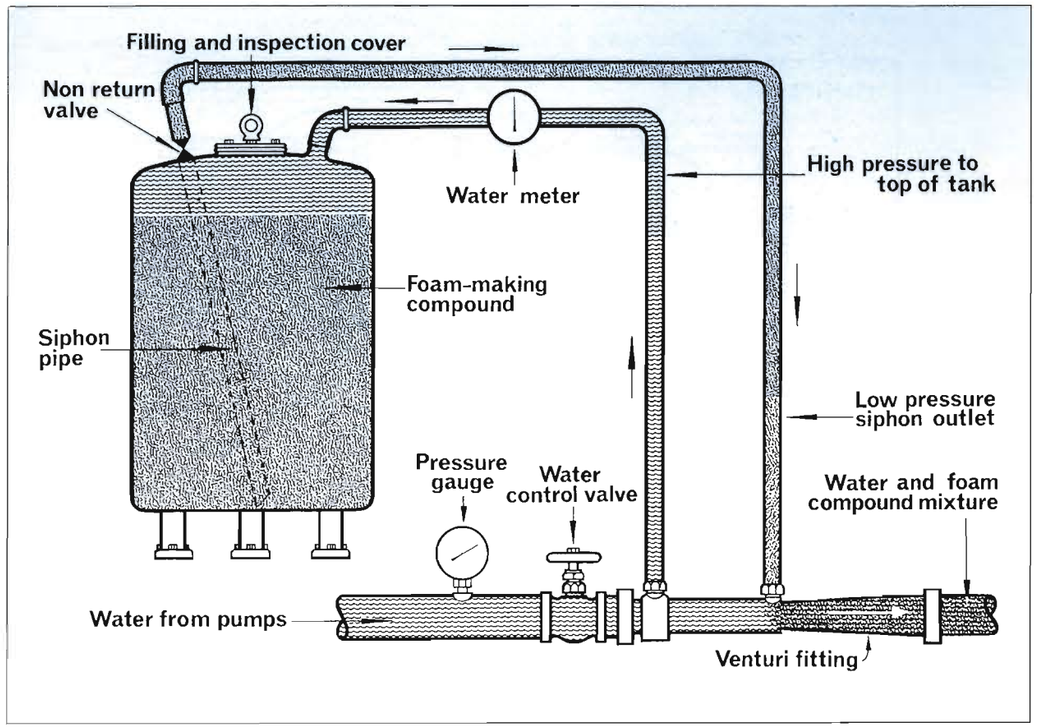


Figure 2.2 Diagrammatic view of pump-operated type of mechanical foam installation.

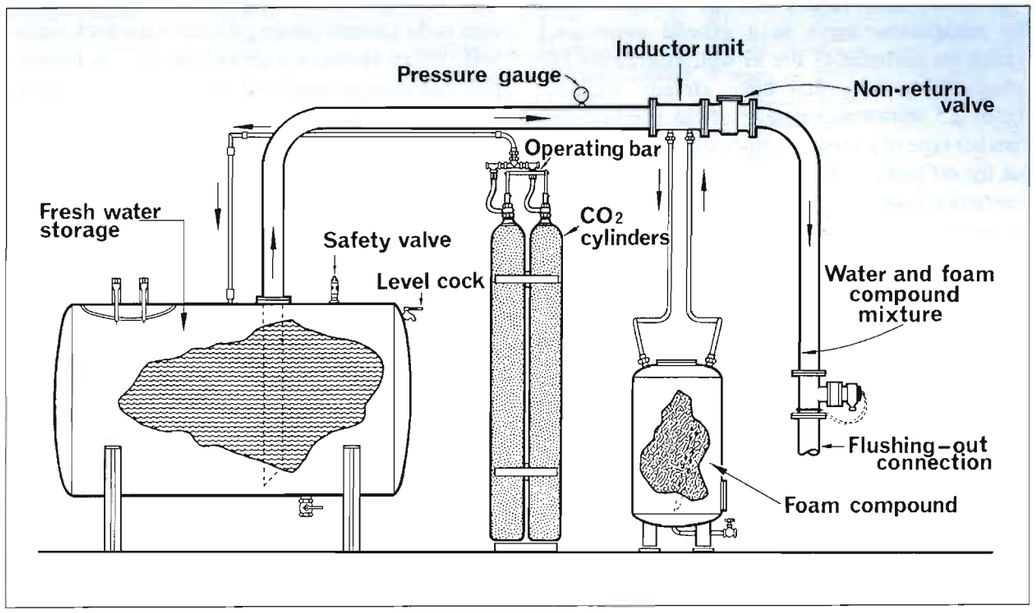


Figure 2.3 Diagram of lay-out of a self-contained pressurised mechanical foam installation.

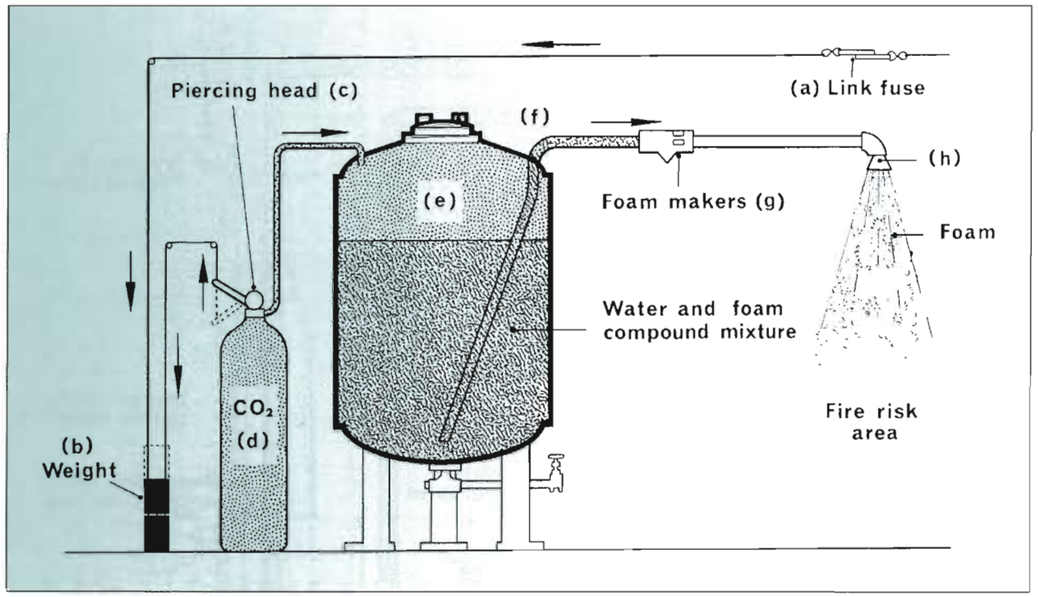


Figure 2.4 Diagram of lay-out of a pre-mixed foam installation.

(e) Inert gas

There are a number of types of inert gas system, varying considerably from one ship to another. They are at present mainly confined to ships holds. The installations serve as a general protection against the outbreak of fire as well as a means of extinguishing fires that have already started. Figure 2.5 shows an example of the combustion chamber type of generator. (It should be noted here that for oil tanker safety, a flue scrubber inert gas generating system is used for fire and explosion prevention, which is different to inert gas generation for the suppression of fire in cargo hold). Diesel oil and air are supplied under pressure to a combustion chamber, from where the burnt gases pass to the cooling chamber and so to the distribution network. Water from the ship's pumps circulates round the combustion chamber to reduce the temperature. From the generator the inert gas passes via a main pipe to manifolds fore and aft and from there, through diverting valves, via individual pipelines to discharge points in each hold.

Systems of this sort, independently generating the inert gas required, are expensive to fit and they take up space. An alternative is the flue gas system, the basic principle of which is that flue gas is drawn from the boiler up-takes and passed through a scrubber (Figure 2.6) which cools the gas and removes most of the sulphur dioxide and trioxide and solid particles. A centrifugal blower then injects the gas into the cargo holds via a deck water seal, which provides a protection against reverse flow and thus prevents hydrocarbons gases passing back into the machinery space. Sometimes a small gas generator is coupled with the flue gas system, so that it is not always necessary to bring the boiler into operation every time more inert gas is required.

Inert gas installations include means of indicating such information as the pressure, temperature and oxygen content of the gas in the inert gas main. They also include alarms to warn of dangerous conditions in the system, and automatic shutdowns when certain pre-determined safety limits are reached.

(f) Halons

No new Halon installation will be found in ships built after the signing of the Montreal protocol, and ships which had previously been fitted with

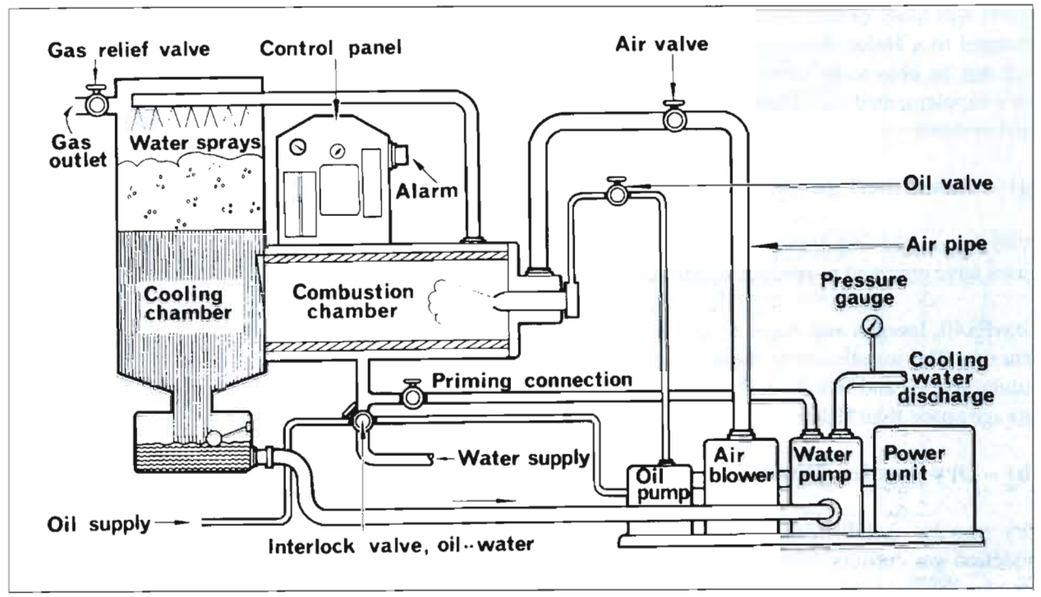
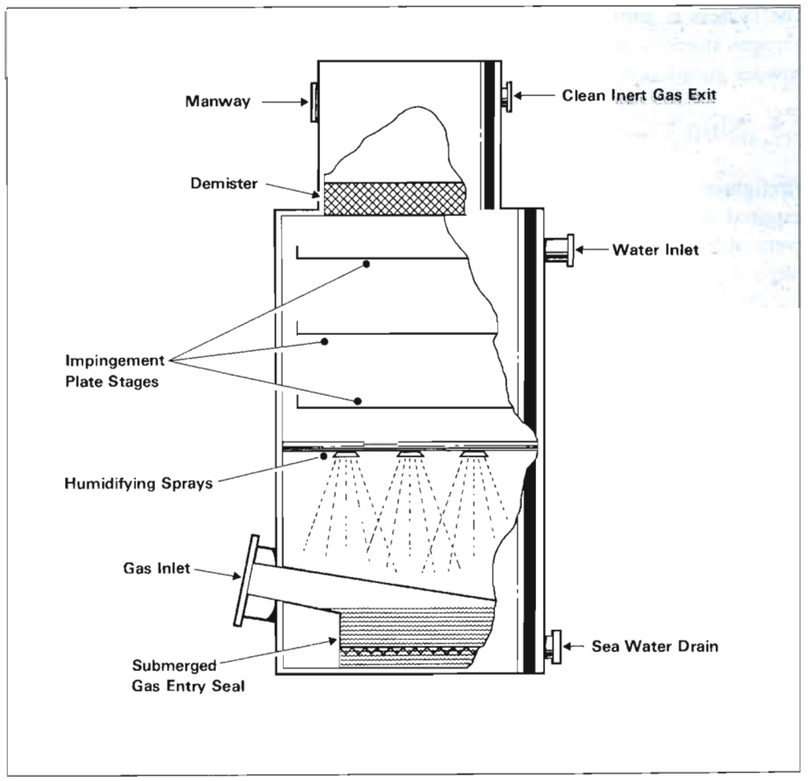


Figure 2.5 Diagram of an inert gas generator.

Figure 2.6 High-efficiency scrubber for a ship's inert gas system. Usually found on deck aft near the accommodation.



Halon will have, or will soon have the installation changed to a Halon substitute as the old systems will not be able to be serviced. Some ships will have supplemented their Halon systems with water mist systems

(g) Other inert gases

With the gradual withdrawal of 'halons', substitute gases have emerged to produce a similar effect.

GravEx40, Inergen and Argonite are some in current use. The installation of these systems will be similar to CO_2 and Halon but they all take up more storage space than Halon.

(h) Dry powder systems

Dry powder installations are found mainly on liquefied gas carriers. Where these are fitted they are usually designed for fighting fires on the deck in the cargo area. There may be two or more powder controls with associated monitors and/or hand hose lines with a nozzle shut-off facility. The system is activated by an inert gas such as nitrogen stored in pressurised vessels alongside the powder installations.

2.5 Ship Plans

Firefighters should note that individual ships are required to carry plans of particular value in the event of fires (e.g. fire control plan, stability plan, cargo stowage plan and pumping plan (Figure 2.7 and Photo. 2.3). They should consult these with the ship's Master, chief engineer, or chief officer. On passenger ships, and on cargo ships of 500 tonne or over, the fire control plan should show, where applicable:

- the position of the control stations;
- the sections of the ship enclosed by fire resisting bulkheads;
- particulars of the fire alarms;
- fire detection systems;
- sprinkler installations;
- fixed and portable fire appliances and fire-fighters' equipment;
- means of access to the various decks and compartments;
- the ventilation system, including particulars of the master fan controls;
- position of dampers and identification numbers of the ventilation fans serving each section of the ship;
- the location of the international shore connection.

This is required to be kept up-to-date and there should be a duplicate of the plan permanently stored in the ship's 'fire wallet' in a prominently marked weather-tight enclosure outside the bridge superstructure. Information may also be posted elsewhere, e.g. at the head of the gangway when the ship is in port.

Photo. 2.3 Cabinet containing 'Fire wallet Plans'.

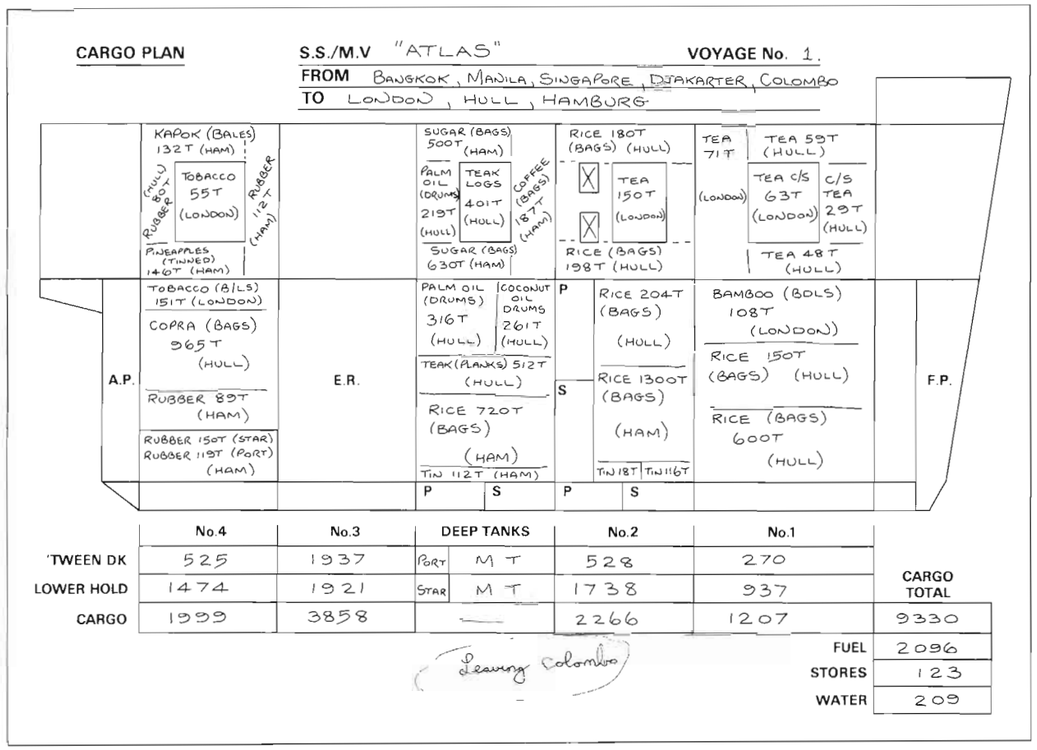


Figure 2.7 An actual cargo plan of a small general cargo ship.

Chapter 3 – Factors relevant to Marine Incidents

3.1 Legislation

The *Fire Services Act 1947* gives the appropriate local councils, as the fire authorities, certain powers and requires them to carry out certain functions. However, remember the writ of fire authorities has limits.

(a) Firefighting at sea

In England and Wales the off-shore boundary of a local authority is governed generally by Section 72 of the *Local Government Act 1972*. This provides that every accretion from the sea, whether natural or artificial, and any part of the sea shore to the low water mark, shall be annexed to and incorporated with the area of the authority which it adjoins; low water mark for this purpose is normally taken to mean low water at ordinary tides. However, in many areas local legislation defines particular parts of the boundary. (In Scotland, there is no equivalent general statutory provision. There, a fire authority boundary may extend to the three-mile limit of territorial water and on an estuary it is generally held to extend to the median line between the estuarial shores; again, the boundary may be subject to local legislation.) Where a fire authority attends a fire at sea outside its area, it does so in the exercise of its power under Section 3(1)(d) of the *Fire Services Act 1947* as amended by the *Merchant Shipping and Maritime Security Act 1997* (see Chapter 6). A member of a brigade engaged in off-shore firefighting operations would be on duty while so engaged, and therefore subject to discipline (and other fire service) regulations.

(b) Firefighting in ports, docks or harbour areas

The *Fire Services Act 1947* applies throughout a fire authority's area with few exceptions. Among those exceptions, however, are docks which are private property and HM Dockyards, and there are also other peculiar areas. Nevertheless, although the powers of access and firefighting of a fire authority do not operate in these localities, there are very few where there is not complete agreement for them to exercise these powers and cover the area. It is fairly obvious that, where there is an impediment to the powers of a fire brigade, the fire authority will have come to an agreement with the relevant organisation as to the exact position of the fire brigade in the event of a fire in the area of that organisation.

(c) Special services

In the case of a special service incident – e.g., a spillage or leakage of a dangerous substance – the powers of a brigade are more limited. At a port, the Harbour Master will be formally in charge, but he may wish to delegate some operational responsibility to the brigade; this should be decided upon during the preplanning (see Section 3). At sea, the Master of the ship will have the overall responsibility.

3.2 Responsibilities

(a) Merchant Navy

The responsibility for the fire protection of a merchant ship will usually depend on where it is and in what 'condition'. Ships under construction are the responsibility of the ship builder. Under repair or refurbishment, they are the ship owner's responsibility unless he has delegated this to the repairer. When a ship is at sea, or in port or harbour, it is the Master who is responsible for his ship and its safety. He can for instance, if he thinks it is necessary, ask for cessation of firefighting and leave his moorings. The Harbour Master, however, has the

ultimate right to refuse entry into a harbour to a ship in a dangerous condition, e.g. on fire, and, if he considers that a vessel constitutes a danger to the port and dock installations, he can have it towed to a pre-planned beaching area accessible to the LAFB.

(b) HM Ships

The commanding officer of one of HM ships has the ultimate responsibility for the safety of his ship and, in the first instance, of the firefighting measures taken. This is also the case where the ship is undergoing repairs or refit and is still in commission. If the vessel is out of commission, the shipyard authorities have the initial fire protection responsibility. On arrival at a fire on board one of HM ships in commission, the LAFB officer-in-charge will liaise with the RN ship's officer of the day to determine whether fire brigade personnel are to be retained 'on standby' or to take over firefighting (see Chapter 5). Flag officers commanding Royal Dockyards have good liaison with the local fire authority and have agreed to firefighters visiting HM ships to acquaint themselves with the risks and facilities. (These arrangements do not apply to visiting foreign warships.)

3.3 Preplanning for Major Incidents

(a) General

The potential for a major incident, even in the smaller ports and harbours of the UK, appears to be increasing. The numbers and size of potentially dangerous cargoes entering and leaving have risen and, despite increasing emphasis on safety by organisations such as IMO, there can, and will be accidents. In any dock, port or harbour, therefore, there must be some preplanning for emergencies (Figure 3.1).

The idea of the plan should be to co-ordinate the actions of all appropriate organisations so as to be able to contain, and deal effectively with, any

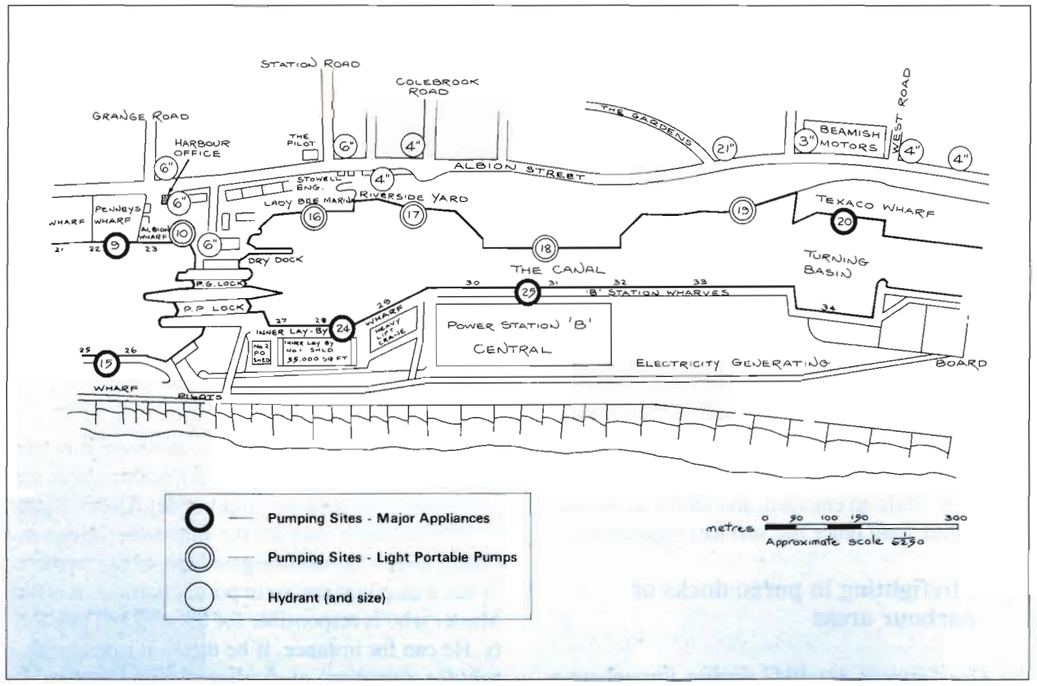


Figure 3.1 Example of part of a brigade plan covering a harbour area.

major incident which threatens the area. Such incidents could involve fire, explosion, massive pollution, or the release of gas vapour clouds, highly flammable substances, toxic chemicals or radiation. They could include accidents during the loading or unloading of cargo at the dockside, or in the warehouses themselves or the approach of a vessel already on fire or suffering from the effects of an explosion and requiring assistance. Preplanning for offshore incidents will also be necessary (see Chapter 6).

(b) Participants

The participants in the preplanning will vary with the size and complexity of a particular marine risk and, apart from the three emergency services (fire, police and ambulance), could include the following:

Port Authority
Harbour Authority
Royal Navy
Dock Board
Port Health Authority
Health and Safety Executive
Tug companies
Department of Transport
Hospitals
Large industrial companies
Shipping companies
RNLI
Maritime & Coastguard Agency
Environmental Agency

(c) Main features of plan

The plan must be flexible but the following points should be considered:

- Methods of raising the alarm and alerting the essential services.
- Establishment of controls and communications.
- Attendance of interpreters where there are language difficulties.
- Control of shipping movements, closure of port, moving of endangered vessels, provision of tug facilities.
- Rescue operations where life is involved; means of escape from berths.
- Provision of craft to ferry firefighters to ships at anchor.
- Equipment for ambulance service; movement of casualties.
- Provision of a series of predetermined embarking and landing points, such that the most appropriate can be selected in any particular incident.
- Facilities for alerting all marine risks, especially if tide/water flow is moving the risk through the area.
- Provision of predetermined beaching points clear of shipping lanes and convenient for the emergency services
- Identification of dangerous substances, decontamination etc.
- Salvage operations, including the containment, and subsequent recovery or dispersal, of oil, chemical or radioactive spillage.

The plan must be practised regularly, modified in the light of the practice, and constantly up-dated.

(d) Controls

There is usually the need, at an incident in a large port, harbour or dock area, for there to be one main control point. Some ports use the Harbour Master's office, but others have different arrangements; for example, at Milford Haven, where the area runs for several miles, the main control is sited at a jetty near the incident. On the Thames the area is divided into two zones above and below Crayfordness. Above, the main control is the Thames Barrier Navigation Centre at Woolwich; below, it is the Thames Navigation Service Office at Gravesend.

There is also a need for forward controls. These should be the normal fire, police and ambulance control units on the quayside, or they could be on board vessels such as fire tugs or marine police

launches or, in some cases on the actual ship involved. **Wherever they are, they must be readily identifiable.** Other minor controls will also operate for BA, equipment, casualties, stability etc, and a comprehensive system of communications is essential.

(e) Communications

The main problem in a situation of this type is the proliferation of wavelengths, call signs and equipment used. The usual solution is to utilise one or two marine radio channels (normally channel 10 or 16). These should be decided upon during the pre-planning process; then, as soon as an incident occurs, they can be taken over and strictly controlled. The emergency service control units that attend port incidents are usually fitted or equipped with this type of radio system, as are fire-tugs, fire-boats and most other vessels.

(f) Language difficulties

It is quite common for firefighters to arrive at a ship and find that no English, or very little, is spoken. This can cause real problems, and the aid of an interpreter would be invaluable. Some brigades have permanent arrangements for calling upon local colleges and universities for assistance.

3.4 Use of Fire and Salvage Tugs, Launches etc.

There are only a few purpose-built fireboats still in use in the UK, but several fire authorities and some industries maintain, or can call upon, fire tugs. In most cases these vessels are normally employed as ordinary tugs in the port area, but are so equipped that they can be called to assist the brigade when required. Photographs 3.1 and 3.2 are examples of fire tugs to be found in British ports. Some tugs carry three monitors, any two of which can deliver a total of 7,200 l/min of water at 8 bar, and also foam at approximately 12,100 l/min. Other facilities include deck connections for hose and foam branches, foam concentrate storage, suction hose and an Aquator salvage pump with capacity of 800 tonne per hour.

Fire tugs come under the control of the senior fire brigade officer for firefighting purposes but the tug master is in control of navigation and the safety of his vessel. Brigades vary in their arrangements, some preferring to put firefighters aboard to help operate the firefighting equipment and others leaving it to the tug master to operate it with the advice of a fire brigade officer. These tugs would be the obvious choice to put men and equipment aboard vessels lying at anchor, but many fire authorities have made arrangements with Harbour Masters, HM Coastguard, Marine police, Conservancy boards etc., for launches, mooring vessels and various other craft to be made available for transporting firefighters and equipment from specified embarking points to the moored ships.

3.5 Pollution

The possibility of pollution occurring at any incident involving vessels afloat, loading, unloading or of cargoes in dock areas needs to be considered.

The Environmental Agency has the responsibility in England and Wales for protecting the environment as a whole, namely air, land and water. The relevant legislation being:

- The Environment Protection Act 1990
- The Environment Protection Act 1995
- The Water Resources Act 1991
- Radioactive Substances Act 1993

There are also other references in the Water Industries Act of 1991 and the Salmon and Freshwater Fisheries Act 1975.

A Memorandum of Understanding (MOU) between the Local Government Association and the Environmental Agency on Fire Service issues is in being and will be updated periodically to ensure effective co-operation between Fire Brigades and the Environmental Agency. The main aim of the MOU is to minimise the hazard to the environment from Fire Service activities, including firefighting and hazardous materials incidents, and to encourage liaison and formulate preventative measures at the planning stage for special risk sites where there is the potential for pollution to occur during an incident. Some brigades will have local contacts with the Agency Region covering their area.

Photo. 3.1
Fire Tugs at Humberside.

Photo. 3.2
Fire Tugs at a marine terminal.

It is not possible to identify all types of incident which the Environmental Agency should be advised of but the following is an example of some of which the Agency would like to be informed:

- 4 pump incidents (with 2 or more jets in use)
- Spillages of Hazchem listed chemicals
- Spillages of low hazard products with polluting potential.
- Petrol spillages greater than 100 litres.
- Other oil spillages greater than 25 litres.
- Incidents involving the use of foam (car fires excluded)
- Exercises involving foam (unless in designated test area)
- Major incidents in areas known to be on a combined drainage system.
- Incidents by/near a water course.
- Incidents at Agency identified risk sites.
- Incidents where the Local Authority 'Major Incident' plan is activated.

- Incidents involving hazardous flytipped materials.

- Incidents involving radioactive materials.

Lists of low hazard materials and quantities which may present a pollution potential are shown in the full MOU or can be obtained from the local regional agency office.

An Environmental Agency officer may attend such incidents but is unlikely to be present in the early stages of an incident. Incident Commanders should bear in mind the possible need for either dilution or containment of contaminants, and seek advice as soon as possible.

In the marine environment the controlling legislation is the *Merchant Shipping (Prevention and Control of Pollution Order) 1990* and its subordinate legislation the *Merchant Shipping (Dangerous Goods and Marine Pollutants) Regulations 1997*. (See Chapter 7)

Marine pollutants are classified by different criteria to the classification of environmental pollutants The international anti marine pollution conventions are embodied in the International Maritime Dangerous goods (IMDG) Code which identifies those substances which should be classed as such.

The Maritime Coastguard Agency (MCA) are in charge of the pollution aspects of incidents. In general, marine pollutants can be jettisoned if necessary for the safety of the ship and its crew, but the MCA must be immediately informed via the nearest coast radio station as outlined in the reporting procedures in the supplement to IMDG Code.

Marine pollutants will carry the marine pollutant mark (Figure 3.2) and the ship and the agents will have a plan showing where they are stowed on board.

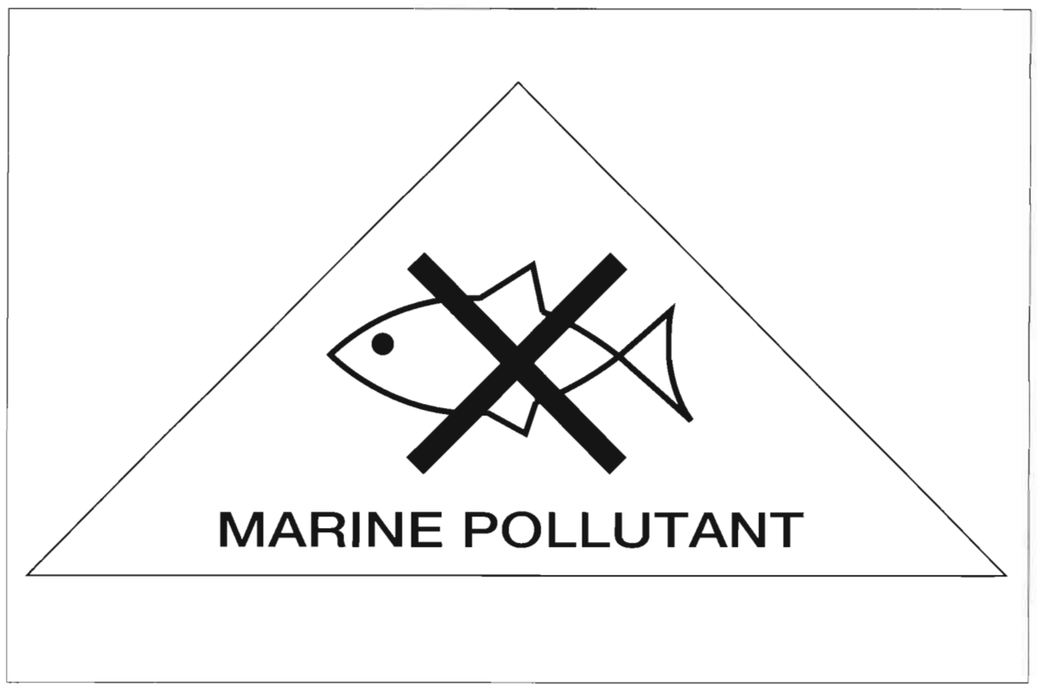


Figure 3.2 The Marine Pollutant Symbol.

3.6 Salvage

Salvage is subject to maritime legislation which confers on those persons who voluntarily save some description of maritime property from danger at sea, a right of salvage remuneration which is payable from the value of the property restored to its owners. To claim to have salvaged a vessel the claimant must be qualified to take control of the vessel, overcome the danger to the vessel, and bring it safely to a place of safety. The contractual arrangements for the salvor to take control of a vessel is the Lloyds Open Form (LOF) which allows that the salvor only gets paid if the salvage operation is successful and the vessel and cargo are taken to an agreed place of safety. The LOF agreement is a proven system which allows a speedy response from owners, agents and insurers so that the salvors can get on with the job. Any subsequent dispute over the salvage is settled by arbitration.

It is doubtful whether a fire brigade could actually salvage a vessel on its own as there is unlikely to be anyone qualified to take charge of the vessel and bring it to an agreed place, or likely that any harbour authority would allow such a person to even attempt such an operation within the area that it controls. The more likely situation is one where the brigade provides a service to the owners or the salvors for which a claim for remuneration is made. Any such contractual agreement would need to be considered by the fire authorities' legal department prior to the brigade declaring its services for off-shore firefighting so that incident commanders know how to deal with the situation should it arise.

Any ship fire being tackled at sea within the normal operational boundaries of a brigade may not result in a successful salvage claim by the brigade as it may be argued that the brigade is performing its proper duty under the 1947 Act. (See Section 3.1 (a) above)

Chapter 4 – Stability

4.1 General

The officer in charge of firefighting operations must constantly bear in mind the stability of the ship. This can be affected by various factors, in particular:

- the amount and position of water put on board for firefighting;
- the amount and position of water pumped out from parts of the ship;
- The movement of cargo etc., from one part of the ship to another.

Stability is a complex subject and to assess precisely, the stability of a ship at any given time and the exact effects different actions have on it, involves complicated calculations. The ship's officers are the experts, and the incident commander should liaise closely with them as they determine the relevant information on the weight of water and the area where it is acting, movement of cargo, ballast, fresh water and fuel oil.

Most ship Classification Societies such as Lloyds, ABS DNV etc., would also have their computer damage control teams. The teams were set up primarily to deal with stress, stability and pollution problems in the event of a collision, grounding or explosion, but could equally be utilised in a fire/flooding incident. These are office based teams who may be activated at any time of the day or night. From information they already hold on ships the team can feed information into their computers and come back with answers on stress and stability. Not being involved on the ground they are able to provide sound solutions quickly. However, there may be occasions when there are no ship's officers present, or where communication with them is hindered by language difficulties, and no other qualified persons may be available. In any case, firefighters should have a knowledge of the main principles involved so that they understand what is likely to happen during firefighting operations, and what factors they must keep in mind. It could take less than an hour for a ship's stability to be endangered by the addition of water if the situation is not handled correctly. This chapter therefore sets out certain basic facts concerning stability; brigades should ensure that all officers receive further instruction in the various principles and procedures as necessary.

Longitudinal Stability

The ship's longitudinal stability, will need to be borne in mind, especially if a large amount of water has to be introduced at one end of the ship, or there may be an excessive trim with the ship down by the head or stern, needing deeper water to remain afloat

Transverse Stability

The difference between heeling and listing should be understood. A **list** is the transverse inclination of a ship due to the **distribution of weight within the ship**. **Heel** is a transverse inclination **due to an external force**, e.g. wind or wave.

The main problem, however, is transverse stability, and this is dealt with in the following sections which have been written by mariners especially for firefighters.

4.2 Buoyancy

When a ship floats in water, it experiences pressure exerted by the water, acting at right angles to the hull, this pressure increases with depth. In calm

water the forces caused by this pressure will be the same on both sides of the ship, but the upward force is only balanced by the weight of the ship and its cargo. If weight is added to the ship it will sink in the water until the increased pressure again balances the new weight. A ship always displaces its own weight of water (Figure 4.1).

The force of buoyancy 'B^{y}' may be considered as though it was a single force acting vertically upwards through the centre of buoyancy 'B' (Figure 4.2), which is at the geometric centre of the underwater portion of the hull and its position alters as the ship heels or trims. When the vessel is upright, the geometric centre will be on the centre line of the ship. When the ship inclines, 'B' will move towards the low side because of the change in shape of the submerged part of the ship (Figure 4.3).

4.3 Gravity

The weight of the ship and its contents 'W' can be considered as though it were a single force acting vertically downwards through the ship's centre of gravity 'G'. The position of 'G' is determined by

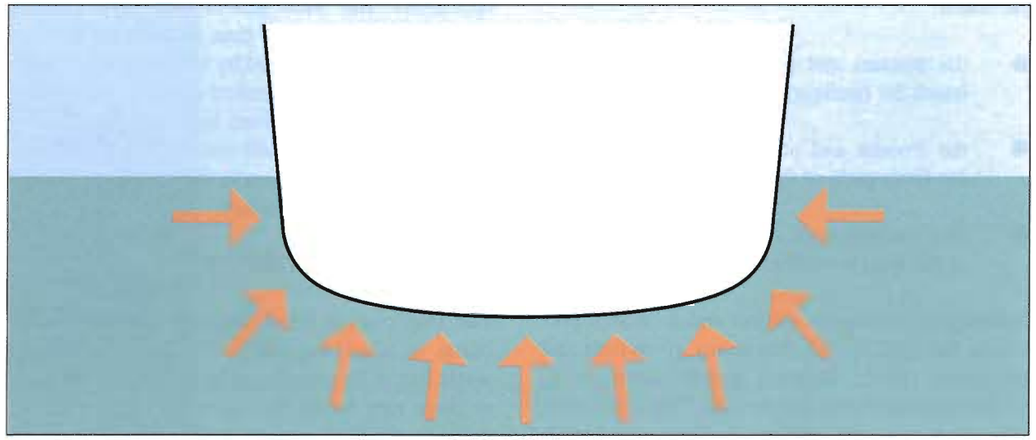


Figure 4.1 Diagram illustrating how a ship always displaces it own weight of water..

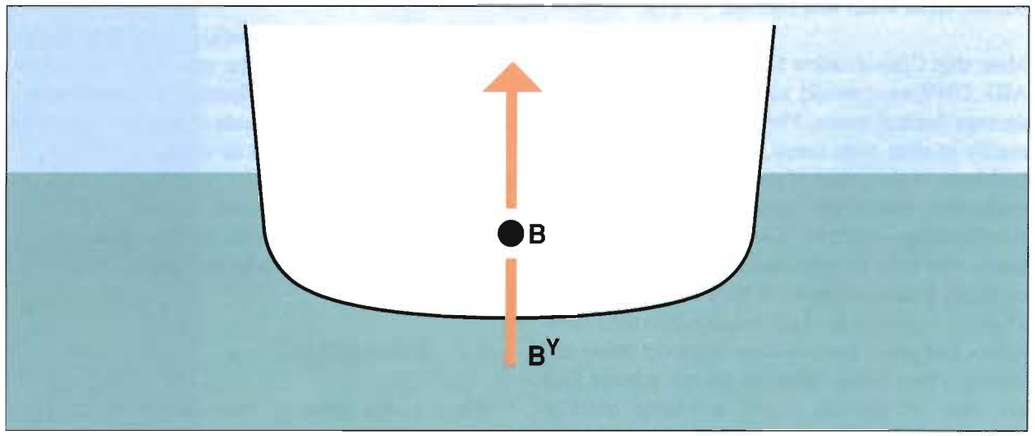


Figure 4.2 The force of buoyancy as a single force acting vertically upwards through the centre of buoyancy.

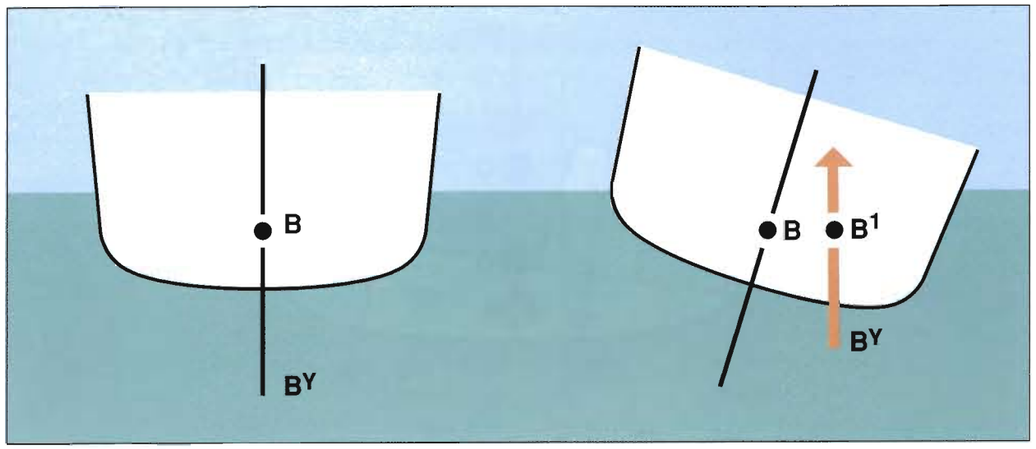


Figure 4.3 Movement of the centre of buoyancy as ship inclines.

the weight distribution within the ship and is not a fixed point. 'G' will move towards an added weight, away from a removed weight and will move on a line parallel to any movement of weight onboard. When the ship is upright, 'G' will also be on the ships centre line (Figure 4.4).

4.4 Equilibrium and Heeling

When the two forces are equal and opposite and acting in the same straight line (Figure 4.5), the ship is said to be in equilibrium. If the ship is loaded evenly then this equilibrium will be when the ship is upright. If when the ship is heeled the ship returns to the upright rather than capsizing, the ship is said to be in stable equilibrium or to 'have stability'.

When a ship is heeled over by the effects of wind and waves, assuming for a moment that these external forces will not (to any great degree) alter the weight distribution within the ship, 'G' will remain on the centreline. But when the ship inclines, the shape of the underwater portion of the ship will change and 'B' will move off to a new geometric centre, the beamier (wider) the ship the further out it moves, until the deck edge is submerged. The force of gravity acting downwards at the centreline

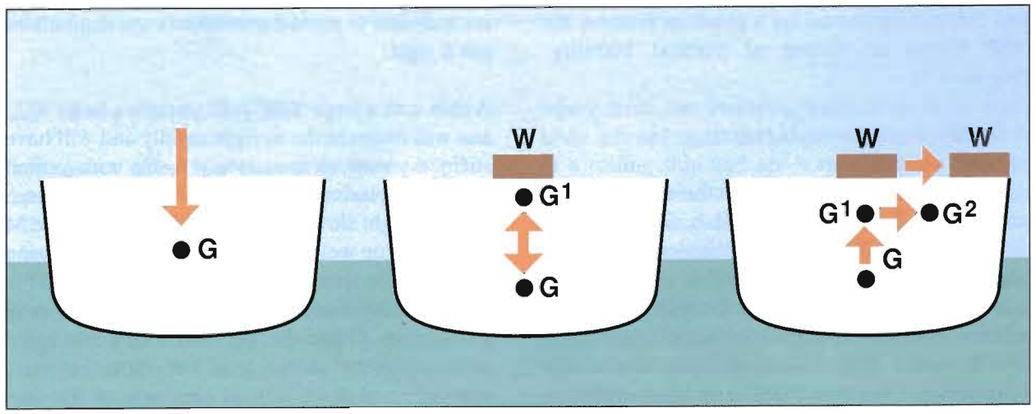


Figure 4.4 The effect of weight on a ship's centre of gravity.

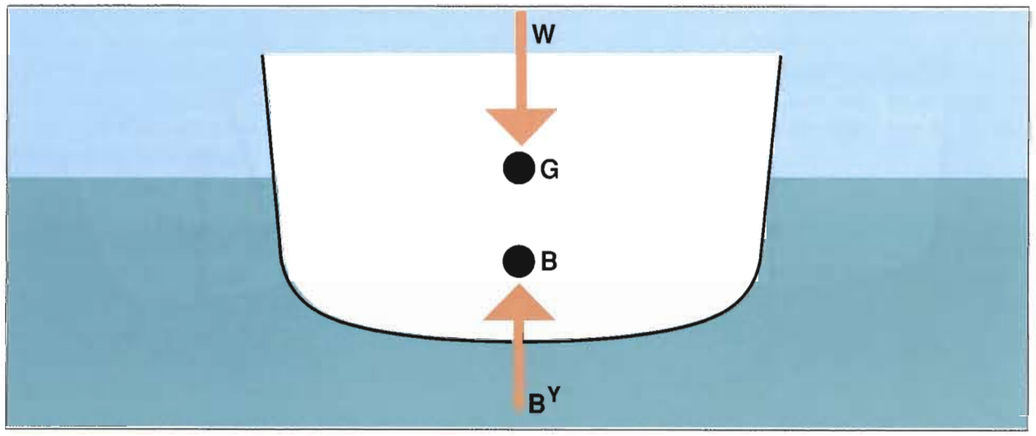


Figure 4.5 Ship in equilibrium.

and the centre of buoyancy acting upwards on the low side together return the ship upright again. The further apart the two forces become, the greater the turning force to bring the ship upright. This is represented by 'GZ' in the diagram and is called the righting lever (Figure 4.6). Note that a ship could be initially stable when upright and be stable to a small angle of heel or a large angle of heel depending on the ship design.

If G is raised in the ship by adding top weight, eventually when the ship is heeled, G will be outside B and the two forces will act to increase the heel. The ship would be said to be unstable, and GZ is now a capsizing lever.

The value of 'GZ' varies with the angle of heel and this can be plotted on a graph to produce the 'GZ' Curve or 'Curve of Statical Stability' (Figure 4.7).

4.5 Metacentric Height

As can be seen 'GZ' varies with the angle of inclination and, if the ship is not slab sided (straight sides), it may also vary with the draught or displacement of the ship. Since 'GZ' is variable, there is a need for an indication of the ship's ability to return to the upright condition irrespective of these two features. This indication is known as the Metacentric Height or 'GM' and is identified as follows:

- A vertical line is drawn through 'B' when the ship is upright.
- The ship is inclined, 'B' moves to 'B1' as the underwater shape changes and a second vertical line is drawn through 'B1'.
- The intersection of these 2 lines gives 'M', the metacentre which may be considered a fixed point for angles of heel up to about 12 degrees.
- The distance 'GM' is the metacentric height.

Although this can be predicted by calculation, experiments are performed on a new ship by moving weights about and measuring the list with an inclinometer to see if the architects and shipbuilder got it right!

A ship with a large 'GM' will produce a large 'GZ' and will return to the upright rapidly and will have stiff jerky motions in a seaway. A ship with a small 'GM' will produce a smaller 'GZ' and will return to the upright slowly. Note that if G rises above M by adding top weight, the result will be a capsizing lever and the ship will be unstable. However M is not stationary and at a large angle of heel, M may move above G and the ship becomes stable again at what is called an 'angle of loll'. Note that there will be an angle of loll on each side of the ship (Figure 4.8).

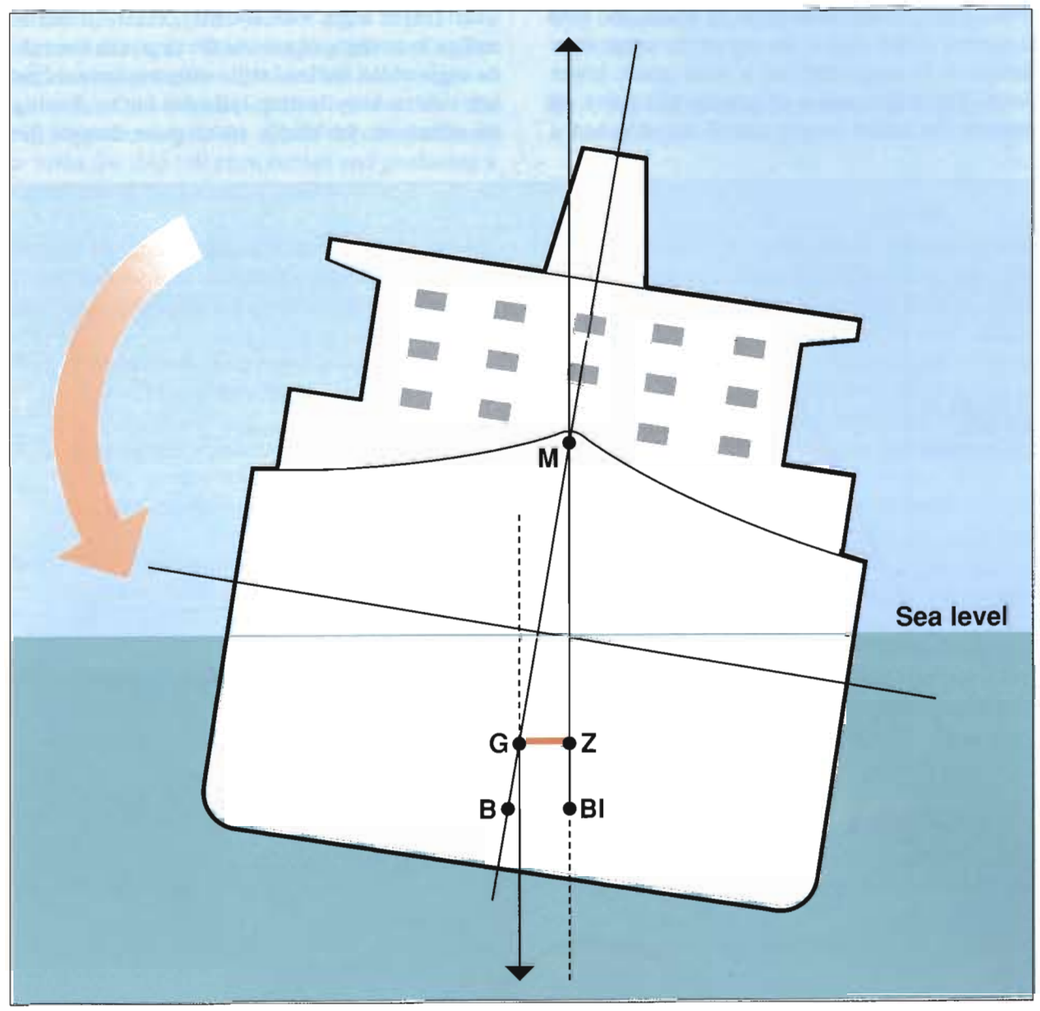


Figure 4.6 Illustration showing righting lever (GZ) and metacentric height (M).

4.6 Free Surface Effect

Free surface effect is produced by water, or other liquid, in a compartment which is not completely full. The liquid will move across the compartment when the ship heels or lists.

Some idea of the effect of free surface on the stability of a ship can be experienced by suspending a weight of about 1 kilogram on string from the end of a 1 metre long stick held nearly upright but inclined away from the body sufficiently to avoid injury from the swinging load. Now sway your body left and right as though you are on the deck of a rolling ship and see what effect the moving weight has, this is similar to liquid moving about in a rolling ship. Better still, get a square plastic sandwich box and float it on water, put some solid weights in the bottom of it, try to roll it to one side and you will see that it is stable. Now gradually pour water in to the sandwich box and see the effect on the stability as you incline it from side to side. Repeat the experiment with more or less solid weights.

When a ship-board crane picks up a load, the load is applied to the ship at the top of the crane even though it is suspended on a wire much lower down. The ship's centre of gravity will move up towards the added weight and if the ship had a small GM to begin with, she may become unstable and go to an angle of loll. As the ship rolls towards its angle of loll the load will swing out towards the low side making the ship roll even further, having an effect on the ship's stability as though the centre of gravity had moved even higher – a 'virtual' rise in G. This swinging effect of a free load is similar to free surface effect as a weight of water slops towards the low side when a ship rolls and keeps moving up the side of the compartment, to make the ship roll even further and producing a virtual rise in the centre of gravity.

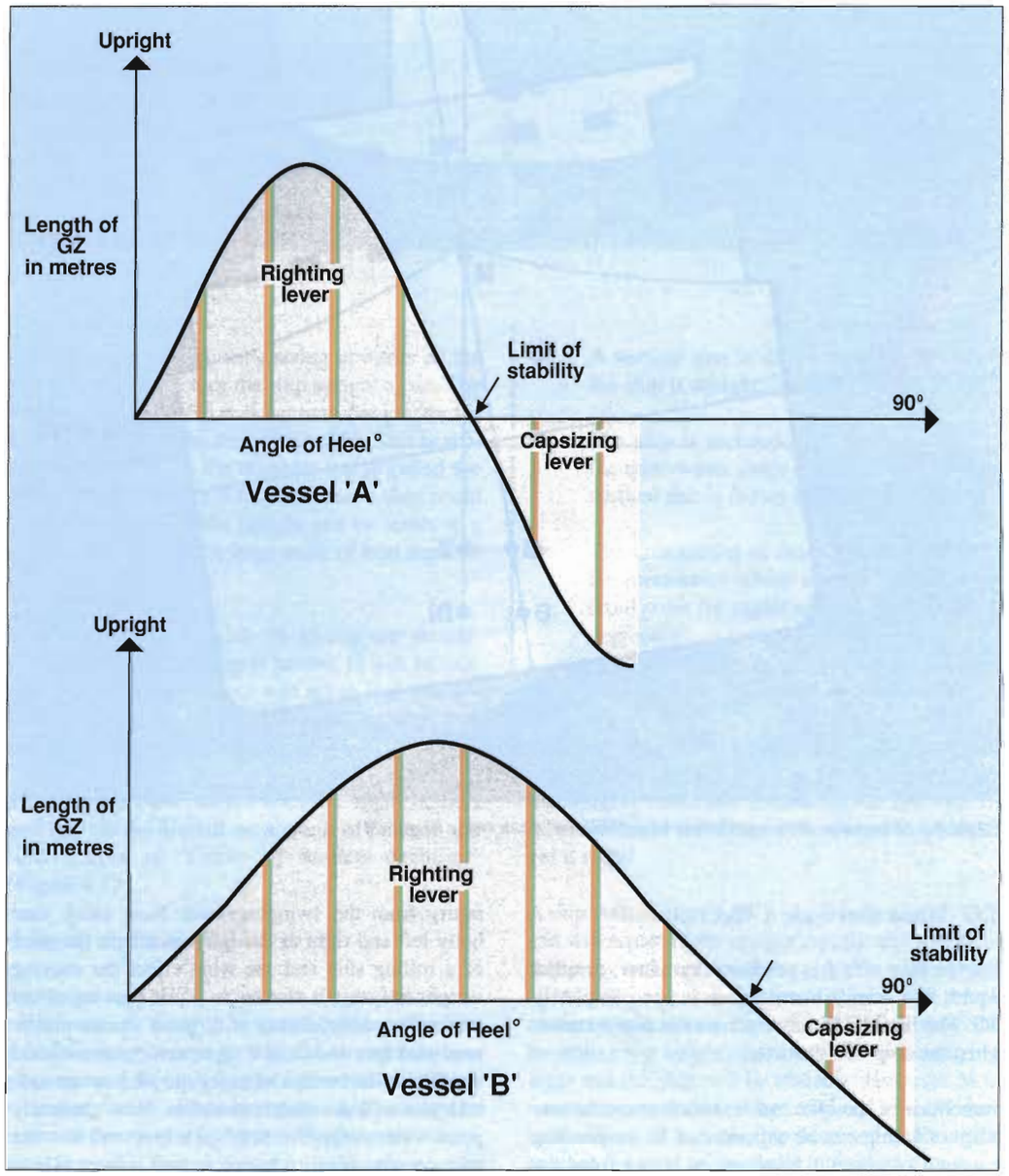


Figure 4.7 Vessel 'A' has good initial stability when inclined but does not have a very wide range of stability and is in danger of capsize at a relatively small angle of heel.
Vessel 'B' does not have as good initial stability, but has a much wider range of stability and could withstand being heeled or listed to a much greater angle without capsize because of a positive righting lever.

During firefighting water may collect in various compartments. Free surface effect is due to sideways movement of weight in the surface of the liquid.

- Free surface effect is the same whether it is high or low in the ship.
- Free surface effect is dependent on the area of free surface and most importantly the breadth in relation to the size of the ship.
- Weight of water low in the ship will increase stability but free surface effect will reduce it.
- Weight of water high in the ship and the free surface effect will both reduce stability.
- Unevenly distributed weight may cause a list.
- Loss of stability may make the ship go to an angle of loll.

4.7 List or Loll?

As will be seen from the above discussion free surface effect is a dynamic thing, due to motions produced when the ship is moving in a seaway. When a ship is rolling in a seaway, loss of stability will be apparent in the motion of the ship. In still water it is very difficult to judge whether a ship is inclined because of uneven distribution of weight, a list, or due to poor stability, a loll, although if there is a lot of free surface water in wide compartments it may be obvious that this is the problem.

The problem is that even in still water the situation may become dynamic if for any reason the ship flops over to the angle of loll on the opposite side. The movement of the ship and the loose water within it may cause the ship to roll past the angle of loll and she is in danger of

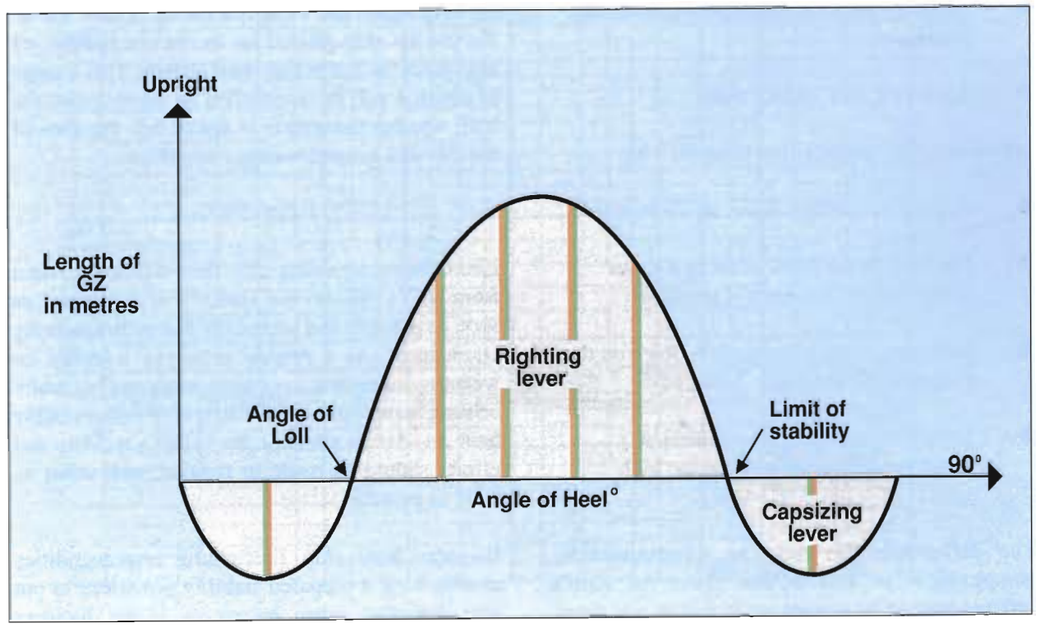


Figure 4.8 This vessel would not remain upright for long. As soon as she is inclined from the upright, GZ is a capsizing lever until she reaches her angle of loll. However, this vessel still has a wide range of stability at her angle of loll.

capsizing. At least dirty firewater may damage areas of the ship not previously affected and firefighters may be injured by the surge of water and movement of loose objects. The ship could also be pushed over as it settled on an uneven bottom.

What could cause this situation is if a loll is mistaken for a list and inappropriate counter-measures were taken.

Action to correct list

- Adding weight on the high side.
- Transferring liquids from low side to high.
- Transferring solid weights from low side to high side.
- Jettisoning top weight from low side.

Action to correct poor stability (Angle of Loll)

Reducing 'Free Surface Effect' by:

- Topping up low compartments containing liquids.
- Removing free surface water.

Improving ship stability (lowering 'G') by:

- Adding weight low down on the low side.
- Draining down flood water to a lower compartment (narrower if possible).
- Ballasting compartments low down on the centreline or low side.
- Jettisoning top weight symmetrically about the centreline or from the high side.

The difference can only be determined by computation so that advice from the ship's officers should be sought, or if that is not available then from salvage or marine experts (see pre-planning).

However, information they would need may only be available from firefighters.

- How much water is being pumped into each compartment.
- How much water is accumulating.
- How much water is draining down.
- Simple reports like the depth of water in an alleyway may be valuable.

In the past fire fighting has been abandoned because free surface calculations were performed for the whole width of a compartment, when on a ship with a list the water remained in a pocket on the low side with a much smaller actual free surface.

4.8 Vessels in Shallow Water

Most ship fires will be fought in a port, dock or harbour in comparatively shallow water. If the vessel settles on the bottom in an ebbing situation, there will be an upward force exerted on the hull which will have the effect of raising the ship's centre of gravity and thereby making it less stable. Should the ship ground on an uneven bottom, its attitude in the water may well change. This change in position will be determined by the shape of the hull, whether the ship is in list or loll, the state of the tide and general weather conditions.

4.9 Stability Procedures

Fire Officers attending ship fires should ascertain from ship's officers the stability of the vessel as soon as possible and preferably before fire fighting commences. As a general principle, it would be wise to assume that any fire fighting and boundary cooling water introduced into a ship will probably have an adverse effect on the vessel's stability and efforts should be made to remove such water as soon as possible.

Brigades with ship firefighting responsibilities usually have a prepared stability procedure to put into operation when necessary. If the Incident Commander decides that the procedure should be introduced, he will usually designate an officer to be Stability Officer and require him/her to carry out the procedure. The duties of a Stability Officer vary slightly from brigade to brigade, but would include:

- Securing a number of firefighters to act as stability crew and, if possible, identify them by specially marked jackets etc. so that it is generally understood that they cannot be used for any other purpose.
- Establishing contact with the ship's officers and harbour officials, if present, and obtaining plans of the ships pumping system, accommodation, cargo stowage (if applicable), water ballast and fuel tanks, firefighting equipment etc., together with any cargo manifest, and a report on the current state of the various tanks. Most of this information should be available in the ship's 'fire wallet' (see Chapter 2, Section 2.5).
- Setting up a stability point, e.g. a position by the ship's inclinometer, ensuring that the incident commander is aware of its position, and establishing communications with him from there. If the ship's inclinometer is inaccessible due to smoke or heat, or is likely to become so, the brigade's portable inclinometer should be set up in a prominent position on deck amidships.
- Obtaining all the relevant information and completing the stability board, an example of which is shown in Figure 4.9. The information on this board should be up-dated at intervals of about half an hour, and the incident commander informed of any

CTR. = CENTRE. LOC'TN. = LOCATION.
ST. BD. = STARBOARD.
T.P.H. = TONS PER HOUR.
R/T. = RUNNING TOTAL.
D/B. = DOUBLE BOTTOM.

STABILITY BOARD.

STATE OF VESSEL. | STABILITY FACTORS.

TANK	FRESH WATER.	BALLAST WATER.	OIL FUEL.	DIESEL FUEL.	CARGO OIL.	CAPACITY. PORT	CTR	STBD	CONTENTS. TIME	PORT	CTR	STBD	WATER ADDED BY FIRE SERVICE. TIME	LOC'TN	T.P.H.	R/T.	WATER ADDED BY SHIPS P.S. TIME	LOC'TN	T.P.H.	R/T.	FIREFIGHTING WATER. TIME	LOC'TN.	T.P.H.	R/T.	REMARKS.
FORE PEAK.																									
AFT PEAK.																									
1 D/B																									
2																									
3																									
4																									
5																									
6																									
7																									
8																									
9																									
10																									
DEEP TANKS																									
WING TANKS																									
COFFER DAMS.																									

TIME	DEGREES OF LIST. PORT.	STARBOARD.	TIME	DISPLACE-MENT.	DRAUGHT. FORE.	AFT.	WATER REMOVED BY FIRE SERVICE. TIME	LOC'TN	TONS	TOTAL	WATER REMOVED BY BILGE PUMPS. TIME	LOC'TN.	TONS	TOTAL	ESTIMATED WATER REQUIRED FOR FIRE FIGHTING. TONS	ESTIMATED TIME OF APPLICTN OF FIREFIGHTING WATER. HOURS

CONVERSION TABLE / WATER

BRANCH	BAR	L/min	TONNES PER HR
12.5mm	4	225	13
16mm	4	340	20
19mm	4	495	28
25mm	3	720	43

Figure 4.9 An example of a stability board used during firefighting operations on board a ship.

significant change in attitude of the ship, i.e. a change in the list or in the draught fore, aft, or overall. Two items not shown in Figure 4.9 are the depth of water and the angle of the bottom under the ship which, as mentioned in section 8, are of some significance.

- Obtaining from the ship's officers an assessment of the amount of water that can safely be put into the section(s) on fire, calculating the approximate time that it will take to reach this limit, and informing the officer-in-charge.

- If necessary, assembling crews, pumps and equipment to pump out or recycle the water back into the fire.

- Checking on any on-board firefighting installations which are in use, e.g. sprinklers, spray systems, ship's pumps, and advising the incident commander as to whether any of these should be shut down.

- The incident commander would have to keep all interested organisations informed of the firefighting and stability position and confer with them on action to be taken to keep the ship safe.

- Corrective stability measures should preferably be carried out before the ship gets into a critical stability condition. (Photo's 4.1, 4.2 and 4.3) Filling a tank low down in the ship may seem a good idea to lower the centre of gravity but will initially cause a loss in stability due to the introduction of free surface liquid. Filling up slack tanks low down in the ship to remove free surface may be a good tactic. When a compartment is partially filled and the ship has a list or loll, the surface of the liquid may not extend the whole width of the compartment, so the

Photo. 4.1 Ship with a fire situation. (Northern Ireland Fire Brigade)

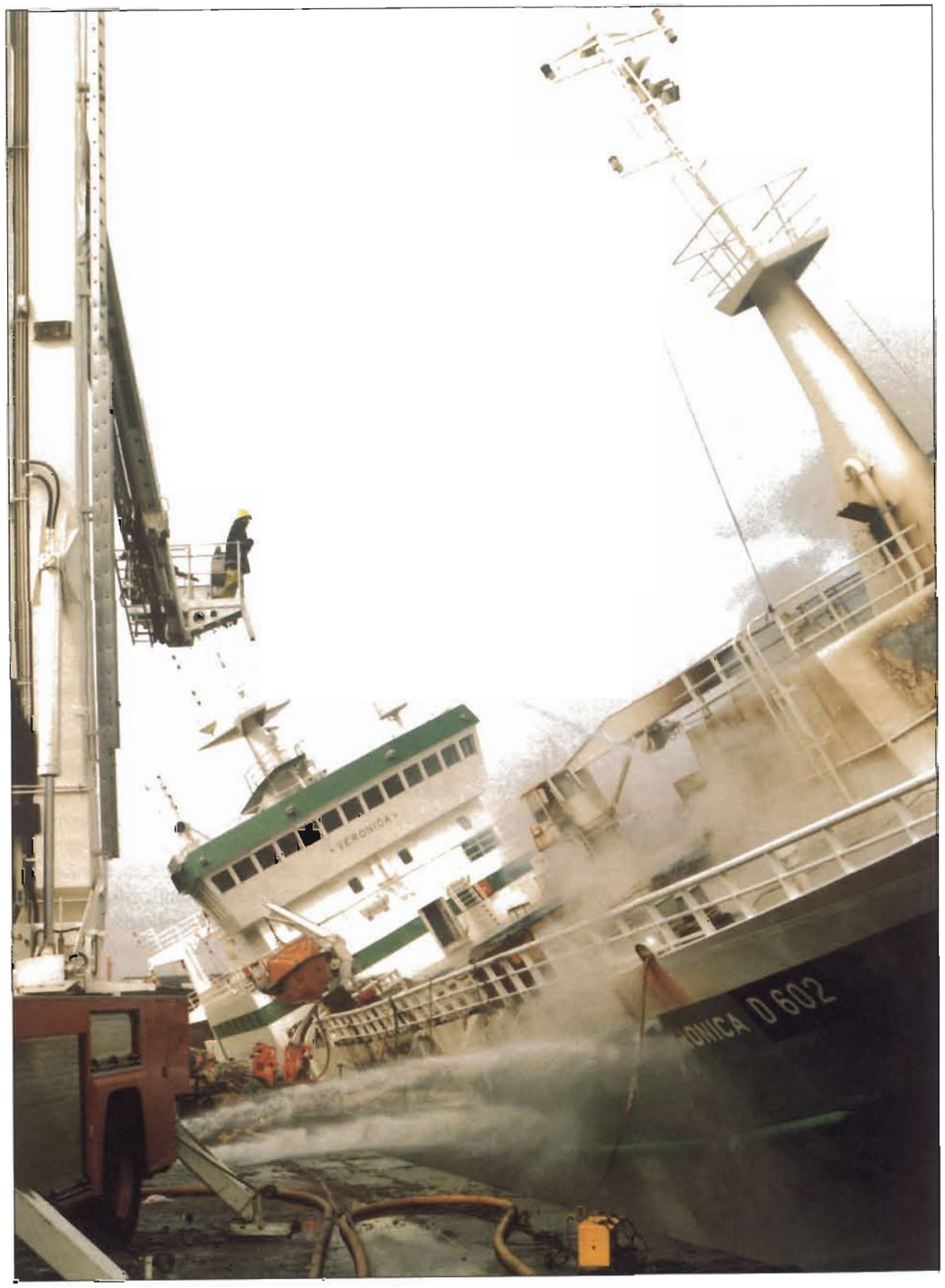


Photo. 4.2 Ship taking on list during firefighting. (Northern Ireland Fire Brigade)

Photo. 4.3
Final list angle – Vessel was restored after fire.
(Northern Ireland Fire Brigade))

actual loss of stability is not as bad as theory would predict. However, the ship's officers advice should be taken.

4.10 Other Considerations

Stability Officers should also bear in mind that certain types of ships have very little freeboard and even a slight settlement or inclination could bring the main deck under water. In such cases, they should be prepared to check that all air-pipes, hatches, doors etc. are closed or protected to avoid uncontrolled flooding.

Checks must be made of all potential openings in the hull near the waterline. In particular, all shell doors and portholes should be examined. In RO-RO vessels, loading door apertures should be checked to ensure that they are properly sealed, unless it is considered safe to use them for access. On very small vessels, care must be taken if a decision is made to use on-board equipment to hoist gear or cargo over the side, either onto, or from, the quayside. The actual lift or swing over the side can cause the vessel to list at quite a steep angle. If there is already an inclination towards the quayside or a large amount of free surface liquid, this sudden list may become unmanageable.

4.11 Collision Damage

Obviously a hole in the ship's hull will also affect the ship's stability and advice should be sought from marine experts on the likely effects and whether the vessel is safe to board.

Chapter 5 – Fighting Ship Fires in Port

5.1 General

To fight any ship fire efficiently, firefighters must be familiar with the basic details of:

- Ship construction and design (Chapter 1);
- Shipboard fire protection and firefighting media (Chapter 2);
- General issues such as liaison with other authorities, emergency plans, responsibility for control of operations (Chapter 3), and safety precautions (Chapter 10);
- Ship stability (Chapter 4).

Within this context, firefighters must have regard to the particular features of different ships, and their present 'condition', e.g. loaded or unloaded, and they must adjust their operations accordingly. Appropriate liaison and preplanning are vital, and Brigades should make every attempt to gain familiarity with, and knowledge of, any specific risks, such as naval dockyards or commercial docks actually located in their areas, together with regular visits to ships visiting such docks or ports. (Photo. 5.1)

Photo. 5.1 Fire in ship in dry dock. *(Merseyside Fire Brigade)*

5.2 Strategy and Tactics

(a) Establishing the situation

The various types of vessel previously described will probably require different methods to extinguish the actual fire using the appropriate media. However, the strategy and tactics employed will be largely similar but will need to be regularly rehearsed to the extent that all personnel are as familiar with what to expect, as they are tackling more general fire situations. More specific extinguishing details appropriate to vessel type is dealt under the vessel type heading.

The first thing a fire officer will do on arrival at any ship is to contact an appropriate person, e.g. the ship's Master or duty officer (Photo. 5.2). The chief engineer or his officers may also be able to help with expertise in their own particular field. From them, and from examination of the ship plans (Chapter 2), the fire officer should obtain details of the ship, its cargo, the firefighting measures already implemented, and any relevant

Photo. 5.2
Liaison with Ship's officers.
(Merseyside Fire Brigade)

factors such as the general state of the ship's stability. Information required will include:

- Whether people unaccounted for, and where last seen?
- Location of the fire.
- The nature of the materials involved.
- Details of any dangerous goods stowed near the fire, anything likely to explode, react violently, or produce toxic gases?
- Access to the fire.
- Whether on-board firefighting systems are operating or operable.
- Whether the main and auxiliary engines are operable.
- Whether mechanical ventilation systems are operating or operable.

Usually, the shipboard installations will be in operation. When this is not the case, the best course will usually be for the Brigade to employ its own equipment, using any helpful facilities on the ship as necessary. The ship's personnel will usually be able to assist by operating doors, pumps, valves etc., and acting as guides. If ventilation equipment is running when the Brigade arrives, the Incident Commander will need to consult with the Master or his engineer as to whether this should be turned off.

Modern ships make increasing use of electronic apparatus, which can bring problems in the event of a fire. For example, there is increasing use of computers for cargo manifests. A fire could prevent a 'read-out' being obtained, but there is often an alternative source at the shipping company's headquarters. This, however, could be anywhere in the world.

A Dynamic Risk Assessment must be carried out in order to plan the way forward i.e. whether to adopt Offensive or Defensive tactics.

(b) Locating the fire

As in general firefighting, the Incident Commander needs to be where he can be found easily to receive reports and to give instructions (Photo. 5.3). This is particularly so with ships as the honeycomb of decks, corridors and spaces can make it easy to become disorientated and much time could be lost in trying to find an incident commander who has gone to look at the fire or

Photo. 5.3 Forward Control liaison with Ship's officers.

check something, instead of using other personnel to make the checks or enquiries for him. Whether the incident commander locates himself at a forward control point on the ship or at a main control on the quayside will depend on the circumstances of the incident.

If the ship's fire defence systems are still live, an examination of the fire detectors or sprinkler displays in conjunction with the ship's plans may well give a good indication of the location of the fire (Photo. 5.4).

Similarly, the presence of smoke, its density and temperature, whether being discharged from ventilators or other openings will provide further indications to help establish the fire's location. All such intelligence should be assembled and analysed before committing BA teams to search for the fire.

If such intelligence points to a particular deck, a BA team should enter at the most convenient position identified by reference to the ship's plans in consultation with the ship's officers. If initial entry is difficult because of heat it may be possible to approach the fire from the deck below. The

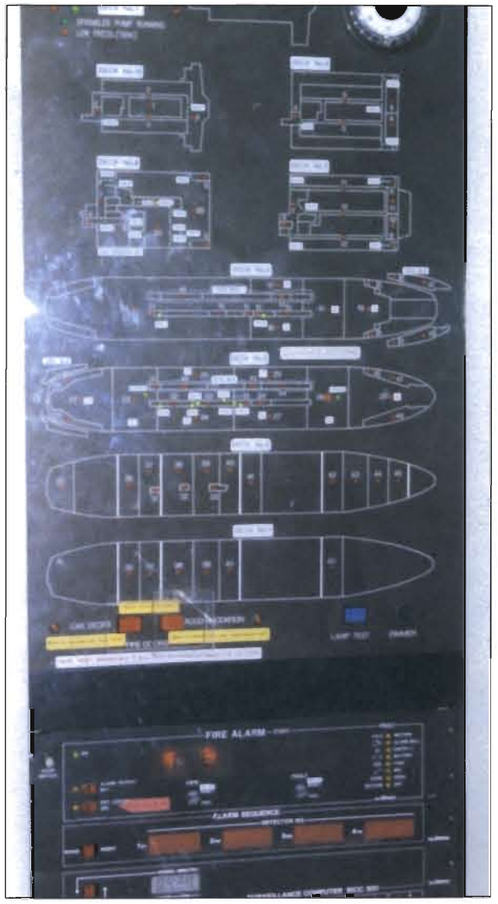


Photo 5.4 Ship's fire indicator panel.

incident commander should consider the use of a thermal imaging camera for both locating the fire and for assessing the effect of the fire on adjoining compartments. At the same time firefighters should carry out checks above and below and around the area identified (Photo. 5.5). The incident commander will require personnel to report back on:

- the limits of any smoke encountered,
- any apparent heat being conducted through decks or bulkheads,
- any particular risk or material likely to assist fire spread,

Photo. 5.5
Fire in superstructure.
(Merseyside Fire Brigade)

- any problems of access if boundary cooling becomes necessary.

Ideally the BA search team will be carrying communication equipment and therefore able to give first hand information back to the BA entry point which should be relayed immediately to the incident commander. There may be known 'dead spots' within a steel hull for communications. Ship's officers may be able to advise on this.

The incident commander will be better able to decide on the strategy for tackling the fire by reference to the combined information received from:

- ship's officers or those responsible for the ship,
- the ship's fire detection/sprinkler or other extinguishing system display panels,
- the direct entry BA team,
- the teams checking decks above, below and the surrounding adjacent bulkheads.

Ideally the ship's drawings need to be temporarily secured under stiff transparent plastic in order that all information obtained can be marked on the plans with chinagraph pencil or similar marker. The information sources should be regularly checked and the incident details up-dated on the ship's plans. The incident commander should bear in mind that only with good intelligence will he be properly in control of the incident. He should question reports that are not supported by other information received, and if necessary send in a different team to check.

The initial gathering of information should be completed as quickly as possible in order that the incident commander can decide whether he has sufficient resources to deal with the fire, and if not what additional personnel/equipment he needs.

Photo. 5.6 Fire on ship in dock – shows use of HP.
(Merseyside Fire Brigade)

(c) Approaching the fire

Once the location of the fire has been identified it is important to determine the best route for firefighters to approach it bearing in mind the difficulties of handling hose lines or other equipment in confined spaces (Photo's 5.6 and 5.7). The ship's crew may be able to advise on the route with least problems to negotiate. If the direct route involves firefighters having to suffer too much heat, it may be possible to approach the fire from the deck below (this is more likely in accommodation areas rather than ships holds).

(d) Application of extinguishing media

The choice of media is very important and will be the decision of the incident commander. He should take into account the factors mentioned in Chapters 2, 4 and 7, as well as the availability of particular media at that time and place, and any advice from the ship's officers.

5.3 Use of Water

(a) By branches

An attack on the seat of the fire as quickly as possible is likely to provide the best chance of rapid

Photo. 5.7
Gaining access at lower level.
(Merseyside Fire Brigade)

extinguishment and minimal water damage. If possible, therefore, water should be applied from within using hand-held branches; fresh water should be used if possible to avoid contamination of the ship's equipment or cargo by polluted dock water. BA teams should enter with communications equipment and guides lines, followed by charged lines of hose. Careful supervision of BA will be essential and circumstances, e.g. excessive heat, may make reduced time limits necessary. Firefighters should realise, however, that conditions within the ship may not be as bad as the initial out-rush of hot gases and smoke might suggest (Photo. 5.8).

Because steel structures are good conductors of heat, boundary cooling is of tremendous importance in ship fires. Cooling the outside may remove heat from the inside, provided, as with accommodation areas, the bulkheads are not heavily insulated. Aluminium structures may quickly collapse in a fire unless they are copiously cooled with water.

If access to the area of fire is not possible by the usual openings in decks or bulkheads, it may be necessary to cut through a vertical bulkhead in order to approach the fire from a different point. This is, however, time consuming and not necessarily effective. Cuts must not be made in the hull of the ship, as subsequent listing could bring these holes under the water and cause the ship to capsize or sink. (A check should also be made to ensure that there are no existing openings which could have this effect – see Chapter 4). When a cut is made, firefighters must bear in mind the possibility of there being water behind the bulkhead concerned. They should cut from the bottom up, so that the cutting tool is always above any escaping water, and they should take care that large amounts of water are not released suddenly in such a way as to trap them. The cut should be above where the plates are hottest.

Water spray can be very effective in a ship fire, especially for cooling ship's plates in order to prevent them bulging and possibly fracturing. Spray is also useful in tackling cargoes such as grain, which, if unduly disturbed by jets, could produce dust clouds and possible dust explosions. For cooling the hull, however, jets are generally more effective.

(b) Compartment flooding

There have been occasions when, due to the inaccessibility of a deep-seated fire, a decision has been made to totally flood a compartment or hold.

Photo. 5.8 Fire in ship's hold.
(Hampshire Fire and Rescue Service)

This is usually only done after all other methods have failed and the Master and all other authorities have agreed. The stability of the ship will have to be carefully monitored and the possibility of it settling on the bottom also taken into account. This will be a matter for the Harbour or dock Master to decide.

All side openings to the compartment or hold, whether designed or introduced, would have to be securely plugged before flooding started. There must be upward ventilation for superheated steam and gases or the compartment could be pressurised, a watch should be maintained at these points. The incident commander should ensure that clear lines of retreat are kept open for any brigade personnel used for this purpose.

When the fire is considered extinguished, the hold(s) should be pumped out, the incident commander still maintaining a careful watch on stability. In cases where the ship has rested on the bottom, the 'lift-off' could be hazardous if insufficient care is taken (see Chapter 4).

5.4 Use of Other Extinguishing Media

(a) Carbon dioxide

The use of carbon dioxide is ideal for some cargoes or particular parts of a ship such as machinery spaces as it will penetrate inaccessible positions. The other general advantages of this medium are:

- It will not affect the stability of the vessel.
- It leaves most cargoes undamaged and unaffected.
- Since it is carried as a liquid under pressure, it does not require pumps.

The disadvantages are:

- Some cargoes, e.g. cotton, require the oxygen in the atmosphere to be reduced to a very low level, which will take time and necessitate large amounts of carbon dioxide. Oxidising agents such as nitrate fertilisers give off oxygen when heated in a fire and will support combustion in an oxygen free atmosphere, so that with these cargoes smothering is unlikely to be effective.
- The gas may be slow to penetrate to some parts of the hold, e.g. area blocked off by cargo or the centre of tightly packed bales.
- The gas at its initial temperature is denser than air and will descend to the bottom of the space into which it is introduced, perhaps below the fire. It will mix with the air eventually, but this may take some time to happen.
- The gas has little cooling effect, and the cargo may therefore remain hot for a long time, with consequent risk of re-ignition if the space is ventilated too soon. (See section 7 below.)

When injecting a medium such as CO_2 or foam into a hold or compartment, precautions must be taken against the displacement of hot gases and,

when injection is complete, firefighters should ensure that all openings are closed.

(b) Use of Foam

When considering the use of foam it is well to note the type of foam which may already have been in use either by the actuation of the ship's fixed installation, or applied by the crew using hand applicators.

The use of either low/medium or high expansion foam will depend on the cargo involved or the situation or both. Of the three types of foam; low and medium expansion foams are the more common foams found in ships fixed installations as both types require smaller generators than that required for producing high expansion foam. The advantages of both of these foams are:

- the equipment is more mobile and can therefore be used in more restricted spaces;
- the foam is wetter and heavier than high expansion foam and is therefore less affected by air currents;
- the foam produced can be projected over a longer distance.

The advantages of high expansion foam are:

- great quantities can easily and quickly be generated for filling large areas;
- it requires less water than jets or other foams, therefore reducing damage to cargo;
- it absorbs heat, helps stop fire spread and provides a shield for firefighters;
- it does not affect a ship's stability in the same way as water.

When deciding on foam application, and foam stocks required, officers-in-charge should take into account the likelihood of the first application breaking down due to heat. Convection currents could also initially prevent the foam settling and it will be necessary to vary the rate of application and the ratios to make an extra-heavy attack in the first instance. The use of foam may only be an interim measure to enable a penetration with water jets to be made for final extinguishment, or, in some cases, it may be successful without any back-up. This will depend on the type of material involved i.e. cargo, the depth of the fire in it, and how long it has been burning. In some cases a cargo fire may need several days' work before the incident commander can be sure it is completely extinguished.

(c) Use of Inert gas

If the ship's services are functional it may be possible to produce inert gas and use the ship's facilities to deliver it to the fire area. This option will rely upon the ship's officers to organise and to operate the equipment.

There are now several inert gas systems which use the combustion products of diesel oil. The gas produced, which is heavier than air, consists mostly of nitrogen (about 85%) and carbon dioxide (about 15%); there may be traces of oxygen, unburned hydrocarbons and oxides of nitrogen. The gas is non-corrosive and non-toxic and does not usually react with the cargo. The gas can be produced in a continuous supply for several hours, the quantity being limited only by the amount of diesel available. Because of the plentiful supply, inert gas can be used to flush a space, thus removing oxygen and heat rather than just smothering. This requires a small opening to be made diametrically opposite the injection point to allow the escape of flushed gases.

(d) Self-smothering

It may be that none of the above methods can be effectively employed because of inaccessibility or too hazardous a situation to employ firefighters. Consideration should be given to the effects of doing nothing except sealing the compartment and monitoring the adjacent bulkheads/decks and deckheads. This option can be time consuming and may require boundary cooling. Ship's officers should be consulted as to the likely effects of this course of action.

5.5 Ventilation

Ventilating a fire on a ship is both difficult and unless carefully monitored may cause further fire spread. If the ship has a ventilation system the ship's officers may have already turned it off completely or, if it is possible, turned off that area covering the incident. It is generally a wise precaution to ensure that where installed, ventilation systems are turned off, certainly until the extent of the fire is determined.

Ventilation may be required for the removal of smoke to enable firefighters to check more thoroughly for any hot spots. In such circumstances the incident commander will need to be sure that:

- any residual heat and smoke will not be carried to unaffected parts of the vessel,
- that the venting system components or any trunking are not damaged,
- that he has sufficient personnel to properly monitor the venting,
- that the evacuation of a hot and smoky atmosphere will not induce a draught sufficient to cause any re-ignition.

Venting a fire on a ship in order to release heat and smoke may not be possible except perhaps for ships' holds which are open to the main deck or machinery spaces through flue stacks. Much will depend on the type of cargo as to whether venting will assist firefighting or cause the fire to develop to unmanageable proportions. If after consultation with the ship's officers the incident commander has any doubts it will be better not to ventilate. The option might then be to starve the fire of oxygen and place firefighters in position for boundary cooling.

5.6 General Cargo Ships

(a) Types of cargo

A large proportion of cargo is, of course, now carried in container and other specialist ships. Nevertheless, there are still general cargo ships of the traditional kind, which could carry a variety of large single units, packaged goods and bulk cargoes.

Firefighters must remember that cargoes can be very varied: some are inherently dangerous, while others may become so in their reaction to heat or water. (The question of dangerous cargoes is dealt with more fully in Chapter 7.) Some cargoes, although not chemically dangerous, pose a risk to the safety of the ship, and indirectly to life, because they affect the ship's stability by moving about, or by swelling as a result of the absorption of water. Conversely, the thoughtless use of a fire extinguishing medium, or the wrong medium, can cause unnecessary damage to cargo.

Following a Dynamic Risk Assessment, it may be considered necessary for firefighters wearing BA and using guide lines to enter the holds to tackle the seat of the fire. BA controls should be set up as necessary on different decks. The entry points at each deck level are usually the best positions for these controls. A large amount of BA will always be needed: first crews will probably only be able to lay out guide lines before having to retreat. (Photo. 5.9)

Photo. 5.9 Making entry into hold.
(Hampshire Fire and Rescue Service)

Photo. 5.10
Ship alongside dock, shows use of ladders.
(Northern Ireland Fire Brigade)

The main access gangway to the ship is often adjacent to the accommodation block, and therefore does not provide convenient access to fires elsewhere, such as ship's holds. Brigade ladders could be used as an alternative (Photo. 5.10). However, this could be a problem with the rise and fall of the tide, or if the vessel subsequently takes on a list (Photo's 4.1, 4.2 and 4.3).

When the fire has been found it should, of course, be attacked at once as delay, apart from causing additional damage, will lead to rapidly worsening conditions. In some cases, however, conditions will be too severe for firefighters to enter the area involved, and the fire will initially have to be fought from above.

This will be through the hatch, by directing a jet or spray downwards across the hold in the direction of the apparent seat of the fire, or by the use of special equipment such as the basement spray, the revolving nozzle, the cellar pipe or the elbow-fog-nozzle (see *Manual*, Book 2, Part 2).

Hatch covers are now usually of metal and hydraulic or electrical in operation, although they may have to be forced manually if distorted by heat. Some, however, need a winch or crane to lift them (Chapter 1). Firefighters must appreciate that dockside cranes, or their operators, may not be available and, due to the fire, the ship's derricks may also be inoperable. Firefighters may have to rig their own lifting tackles but this would only be possible on small vessels. Hatch covers should not be removed until firefighting equipment is in position and charged.

(b) Handling cargo

Where it is necessary to move cargo to reach the seat of a fire or to ensure that no fire remains in it, firefighters may have to move it themselves, but whenever possible should get assistance, or at least advice, from a skilled stevedore. Some brigades arrange fork lift truck training for firefighters to enable them to be able to move cargo wearing BA when perhaps the atmosphere is uncomfortable or even toxic. Where Breathing Apparatus is not required it may be best to ask stevedores to the job, while leaving firefighters to carry out any necessary damping down. When any cargo is being moved, firefighters should watch it for signs of fire and keep a branch in position for use if necessary. Particular care is necessary if equipment is used for moving cargo; a grain conveyor belt, for example, can draw up a fire along with the grain. Partially burnt bales should only be opened up away from the scene of operations and any internal fire extinguished by covering jets.

5.7 Container Ships, 'LASH' and Barge-aboard Ships

Containers are usually packed and sealed at the manufacturer's premises, so, provided that they remain intact, there is little chance of their contents being ignited by an external source whilst on board ship, unless a fire becomes well established outside the containers and develops to involve them. The most likely cause of a container fire is a reaction between incompatible chemicals as a result of a leak. An experiment in the Netherlands has shown that a container can usually contain a fire unless a running liquid is involved. Containers may be allowed to burn out without opening if enough boundary cooling can be applied. Some ships and fire brigades carry devices for making holes in containers and injecting water spray or CO_2.

A container could also contain solids which would melt and run in a fire. These are classed as flammable solids in the International Maritime Dangerous Goods code (IMDG). Container ship cargoes could also include large numbers of tanks i.e. large volumes of liquids.

Usually, certain parts of a ship are designated dangerous cargo areas, and containers holding dangerous goods will be located in these areas, e.g. an upper deck or a particular hold. Details of any such goods and their location should be readily available (see Chapter 7).

Apart from the special problems of dangerous goods, any fire involving containers will be very difficult to deal with since the tight storage means that access for firefighting will be extremely difficult, if not impossible, and there could be problems in moving containers. Even with the necessary dockside equipment available, the process will be time-consuming, particularly if fire hinders the equipment's use. If available, modern equipment for unloading containers through the bow (see Chapter 1) could be helpful. Among other problems on container ships are the following:

- Ventilation could be difficult, depending on the location of the container involved.
- If the guide rails (see Chapter 1) become distorted by heat, it will be very difficult to remove the containers. It is therefore important to cool these rails during a fire.
- Some containers are fitted with refrigeration motors, whilst others have flexible piping to the ship's refrigeration system. Holds may be insulated for the carriage of refrigerated containers.
- Should any containers on the ship's deck be, or become unsecured, they could move dangerously.
- On partial container ships, used also for the carriage of cars etc., low deckheads and car lashings can hinder access to the containers.
- Initial access to the ship might be difficult because of the high freeboard and, usually, the single gangway.

A ship's CO_2 installation, if fitted, could be used as the first measure against a fire, but the holds are very large and there might be insufficient supplies to be effective. An alternative is to flood the holds with high expansion foam or, in the last resort, water, although this may take some time.

With LASH ships and barge-aboard ships, the best course if the fire is confined to one particular barge or lighter is to have the affected barge or lighter removed if possible and to deal with it separately after opening up.

5.8 Ro-Ro Ships (including Ferries)

(a) General

Ro-Ro ships vary according to their use. A bulk car carrier may hold several thousand cars, whereas a ferry could be carrying as many as 500 vehicles and 1,500 people. Details of the layout of the two types of Ro-Ro ship are given in Chapter 1.

(b) Evacuation of passengers

Obviously, when a ferry is on fire in port, all passengers will be evacuated as soon as possible. Some modern vessels are being fitted with escape chutes similar in design to those fitted to large

aircraft, but, in any case, firefighters could encounter a large number of people leaving the ship as they arrive. Every assistance should be given to ensure their safe disembarkation. The possibility of some people attempting to return to their cars should be considered.

(c) Access

Methods of access to vehicle decks are described in Chapter 1. Firefighters should note that it may be necessary to wedge open some heavy sliding doors to avoid having hose lines cut and retreat avenues obstructed. There are alternative entrances to machinery spaces, e.g. enclosed ladders passing up through the central section to the top decks.

(d) Fixed firefighting installations

The ship's Master may have operated fixed firefighting installations to try to contain the fire and he will probably be able to tell the incident commander its approximate location. Arrangements should be made so that, when firefighters are in a position to tackle the incident, and if considered necessary, any fixed installations operating can be shut down. This applies to fires in the accommodation and machinery spaces as well as those in cargo areas.

Regular 1(i)d visits should be arranged by Brigades to all types of ships using ports in their area to ensure familiarity and compatibility of the various types of installations, adaptors, fittings and outlets provided.

(e) Fires on vehicle decks

On vehicle decks, there will often be a serious problem of access because of the very restricted space between vehicles. The degree of difficulty will depend on how the vehicles are loaded. It may be necessary to partially unload a bulk car carrier to get at the area of the fire. Firefighters must take extra care when vehicles are being moved by the cargo handlers.

Water jets and/or spray will usually be sufficient to put out the fire. Drainage on the vehicle decks is usually to run-offs at the sides leading to the bilges, but firefighters must be aware of the danger of these being blocked. The vehicle decks may well be fitted with drenchers which when operating will significantly help in restricting fire spread to other vehicles. Any amount of surface water in large areas such as the vehicle decks could seriously affect stability.

BA may need to be worn, depending on how far firefighters have to penetrate.

Some commercial vehicles carried on ferries may contain dangerous substances. Such substances must be notified to the ship owner or Master before being taken on board, and the vehicles concerned are usually isolated in a particular area, e.g. all aft or all forward on the lower deck, or on the top deck in the open air. Details should be easily obtainable (see Chapter 7). An example of a dangerous cargo manifest is shown in Figure 5.1.

5.9 Insulated Ships

(a) General

Fire in insulated ships may occur either in the holds or in the insulation. A fire starting in a hold may, however, spread easily to other parts of the ship via the insulation or air ducts and through the effects of radiated or conducted heat. Firefighting is made more difficult by the large amount of fumes and smoke that can be given off, some of which can be toxic. Involvement of refrigeration plant is a particularly serious cause of fumes. Heavy concentrations of CO_2 may be present in holds carrying citrus fruit even when there is no fire. In most cases, therefore, the use of BA is essential. Usually a ship's engineer will shut off the hold(s) or deck(s) involved and leave the rest of the ship's refrigeration system working.

In an incident involving an insulated ship, the commander of the first attendance should ascertain the details listed in Section 5.2 (a) above, plus the following:

- the type of insulation;
- the type of ducting/piping;
- the nature of the refrigerant, if applicable.

NORLAND SIGNED ..... DATE .....

BKG NO	UNIT NO	UNIT TYPE	COMMODITY F.P.	CLASS PAGE, UN	WEIGHT	SEGREGATION	EMERGENCY ACTION
11	228292	L/T	(DIPHENYLMETHANE – 4 – 4 Diisacyanate) LUPRANATE RESIDUE	PAGE 6093/3 UN 2489 6		AWAY FROM L/Q & FOOD	EMS 6.1 04
14	CBLU 000002	L/T	(BIPYRIDIUM PESTICIDES) REGLONE	PAGE 6146 UN 2781 6		AWAY FROM L/Q & FOOD	EMS 6.1–06
15	100115	L/T	HEXAMETHYLENE DIAMINE	PAGE 8096 UN 1783 8		AWAY FROM 2.4.1.8	EMS 8–05
54	010211	L/T	ACRYLAMIDE RESIDUE	PAGE 6008/2 UN 2074 6		AWAY FROM L/Q & FOOD	EMS 6.1–04
301	LKY 428	TRL	(PESTICIDES) TECHNICAL CONCENTRATE	PAGE 6146 UN 2902 6		AWAY FROM L/Q & FOOD	EMS 6.1–06
302	RT 147	TNK	(ETHYLENE GLYCOL MONOETHYL ETHER) ETHOXOL	PAGE 3134 UN 1171 3		AWAY FROM 2.4.1.8	EMS 3–06
302	RT 147	TNK	(ETHYLENE GLYCOL MONOBUTYL ETHER) BUTYL ETHOXOL	PAGE 6085/1 UN 2369 6		AWAY FROM L/Q & FOOD	EMS 6.1–01
70	3465	L/T	(DICHLORODIFLUOROMETHANE) ARCTON 12	PAGE 2045 UN 1028 2		AWAY FROM 1.3.4.5.8	EMS 2–09
72	3480	L/T	ARCTON 12	PAGE 2045 UN 1028 2		AWAY FROM 1.3.4.5.8	EMS 2–09
						AWAY FROM	EMS

Figure 5.1 Typical list of hazardous cargo vehicles on board 'Norland' passenger/car ferry.

(b) Fires in the holds

A fire in a hold can be dealt with in a similar way to an ordinary cargo fire, but firefighters will have to pay particular attention to preventing fire spread. They should ensure that, where ducts pass through bulkheads, the dampers are closed and secured, and that the ventilating machinery is shut down; and they should watch for signs of heat in bulkheads and partitions adjacent to the seat of the fire. When the hold has non-flammable insulation such as fibreglass and its air ducts can be effectively shut off and guarded, CO_2 and high expansion foam can be used to considerable effect

When gaining access to a hold via a hatch cover, firefighters must remember that there will be one or more insulated plug hatches below this and it may require a crane or derrick to remove them. (Figure 1.12)

(c) Fires in the insulation or air ducts

If the fire is in the insulation or air ducts it will not normally be possible to tackle it by introducing extinguishing media into the holds.

The first necessity will be to locate the seat of the fire. The smoke emerging from the thermometer tubes may give an indication of the deck involved, and closer identification may be possible by feeling for the heat through the bulkhead plates or finding signs of burning.

The use of thermal imaging cameras may greatly speed up this process whilst reducing risk to personnel.

When the approximate seat has been established, firefighters will have to tackle the fire directly. How they do so will depend on various factors such as the thickness of the covering plates and the nature of the insulating material behind them. One way of dealing with an insulation fire would be to cut holes about 150mm in diameter above the seat of the fire and insert branches. Sufficient retaining material should then be stripped away to reach more of the insulation and ensure that no pockets of fire are left.

This is likewise important when there is a fire in the air ducts.

Insulation may consist of materials such as polyurethane foam which give off toxic fumes, and firefighters should in the circumstances, or in any case of uncertainty, use BA. In air duct fires, the closing of dampers (where applicable) is obviously of vital importance.

5.10 Tankers

In general terms, firefighters should deal with fires on tankers as they deal with oil fires on land (see *Fire Service Manuals – 'Firefighting Foam'*, Chapter 6 and *'Petrochemicals'*). Some general guidance is, however, given below.

(a) The risk of fire

The risk of fire varies. Cargoes of heavy oil present relatively little risk. Crude oil is however dangerous, as are petrol and oils having a low flash point. The danger is least when tanks are full and properly sealed. It is the greatest when the tanks have been emptied of oil but still contain gas. The problem will be relieved if proper inerting procedures have been followed (see Chapter 1 and Chapter 2), but this may not have happened, or the equipment might be defective or be made so by a fire or other mishap. Fire and explosions can then be caused by, for example, a spark from metal scraping on a steel deck or even by static electricity. Other tanker fires may be the result of collisions which rupture the tanks. (If damage to the tanks does not immediately result in a fire, a flammable mixture may be formed as air reaches the tanks or gas escapes from them, and this may then reach an ignition source). The Brigade will therefore probably be faced with fire on the superstructure and/or on the surface of the water as well as in the tanks.

(b) Fires in tanks

Usually, a collision and/or explosion will have created a hole in the top or side of the tank, sufficiently large for the efficient application of foam. When oil is burning inside a tank, large quantities of foam will be necessary and the incident commander must be sure to order on sufficient amounts of foam concentrate and an adequate number of foam branches and pumps. The supply of foam must be continuous to be successful and it is better to order on too much rather than to allow the fire to re-establish itself by having too little. Even a relatively minor incident might require as much as 13,500 litres per hour. If fixed installations are in operation, the incident commander should obviously allow them to continue while mobilising his resources.

Foam branches should be positioned to windward so as to be clear of vapour and to maximise the distance of throw. This may be done from the deck of the ship or from a fire tug positioned nearby, depending on the circumstances. Firefighters should concentrate all their efforts on one tank at a time, so that the foam has effect as quickly as possible. Even after a fire has been extinguished, a thick layer of foam should be maintained for some hours until the plates have cooled and the danger of re-ignition passed.

Water should be used for the external cooling of plates but not allowed to enter tanks. Any system for inerting tanks should remain in operation, if undamaged, to protect those which are unaffected. Firefighters should, of course, attempt to discover which tanks are full and which are empty as soon as possible, in order to give priority to cooling full tanks. The ship's loading officer should know the current position.

(c) Other fires

Apart from tank fires there may also be fire in the superstructure. Firefighters should tackle this with water in the usual manner. They must take care, however, that water does not fall onto, and break up, any foam blanket which they may have applied at a lower level.

Oil leaking from a tank or floating on the water, whether ignited or not, should be broken up by powerful jets. By the cooling down and separation of the oil, any fire will be extinguished or made less likely, and fire spread from patch to patch will be prevented.

(d) Other considerations

There may, with the largest tankers, be particular problems in reaching the ship and getting aboard. Chapter 6 discusses the general question of access. When on the ship, firefighters should remember that it is rare to be able to rely completely on the ship's firefighting installations. Some systems run over the top of tanks and are often damaged in an initial explosion.

5.11 Passenger Ships

(a) General principles of attack

The Brigade's Risk Assessment will take into account:

- Type of vessel
- Access
- Availability of supporting resources etc.

A typical first attendance at a fire might consist of four pumps and an emergency tender. The crews should board with equipment including general purpose lines, adaptors, breathing apparatus, Stage 2 BA boards, thermal imaging cameras, delivery hose and variable control branches. On large ships they may be able to get jets to work from the ship's mains, but they will usually obtain their supplies from shore based or water-borne pumps. If there is a sprinkler installation on the ship, they should keep this in operation until the fire is extinguished or jets are in position. On some vessels there may be ship's firefighting personnel and their advice should be sought on the fixed installations; they can also offer guidance round the ship. The incident commander will find it beneficial to assign personnel from his crews to be responsible for such areas as:

- Stability (see Chapter 4);
- Foam;
- Water;
- Staff duties;
- Communications;
- Breathing apparatus;
- Other equipment supplies.

A firefighting bridgehead and BA entry control should be set up on each deck involved, or adjacent to the fire.

(b) Effects of the ship construction and layout

A passenger or cruise ship can be very complex in terms of the number and naming of its decks, its corridors, cabins, public rooms, service areas etc. Not only can it be difficult to locate the fire and easy to get lost but the long corridors and staircase and lift shafts can induce draughts which help fire spread. A ship's officer should meet crews boarding a ship and escort them to the fire; guides should be posted to direct later support or relief crews.

Care must be taken to ensure a line of retreat in the event of an emergency; guide lines (coloured tape) may be helpful in this respect.

Passenger or cruise ships are divided by fire-resistant, and in some cases watertight, doors and bulkheads – see Chapter 1, Section 9 (b). The doors not being used for firefighting should be closed as soon as possible to confine heat and smoke and minimise fire spread. Firefighters must not, however, place total reliance on these to act as fire stops. Doors and bulkheads surrounding the fire should be examined regularly for signs of heating and cooled as necessary.

Watertight doors can be controlled from the bridge, and careful liaison is necessary in order not to shut crews in or sever hose lines. Firefighters should establish manual control of the operation of watertight doors where personnel are working. As a further measure to stop fire spread it is usually desirable to have the ventilation system closed down.

Fire may spread between the ship's side and cabin walls via metal decking, or behind panels and false ceilings, through cable ducts and pipelines etc. Firefighters should therefore check the area around, and above and below the fire, stripping away panelling and cooling down as necessary.

Stability is always a factor in ship fires, but can cause special problems when water is introduced high up in the accommodation of a large passenger ship. The free surface effect of water (see Chapter 4)

is the main danger, especially where it lies in large areas such as the public rooms.

Public rooms can also cause other problems because of their elaborate furnishings and fittings; access through them can be made difficult by the layout of furniture.

The often luxurious accommodation in cabins may be readily flammable, and the situation can be complicated by the use of materials such as foam rubber in mattresses and plastic surfaces which can produce vast amounts of toxic smoke **increasing the risk of early flashover within compartments**. In a small cabin fire, furniture should be left in the cabin so as not to impede passage in narrow corridors.

5.12 Royal Naval Vessels

The issue of responsibility in ship firefighting is complex; this is particularly so with Royal Naval vessels (see Chapter 3). A proper understanding between RN and Fire Brigade personnel is essential, since only this will guarantee effective liaison and co-operation necessary. In recent years issues which had previously been unclear have been clarified by discussion between Home Office, Local Authority Fire Brigades and Admiralty representatives, and promulgated as instructions to both services. The following extract of the advice is applicable to both RN ships, submarines and to vessels of the Royal Fleet Auxiliaries in ports and dockyards.

(a) Responsibility

The responsibility for control and command of any firefighting operations aboard RN/RFA vessels varies as to the state of operational readiness of such vessels at the time of the incident. Generally the vessels will be:

- in commission with an operational crew on board, or
- in an unmanned refit state (afloat or in dry dock) not in commission, in the hands of contractors.

In the unmanned refit state the responsibility for the vessel rests with the contractor carrying out the refit work on the ship. In this state any fire occurring will generally result in the Fire Brigade being called and the incident commander liaising with the main contractor's representative as to safety aspects aboard the vessel. The Fire Brigade incident commander will be responsible for any firefighting but he should liaise with contractors and dockyard representatives.

Whenever RN service personnel are standing by a vessel being refitted under Contract, they are to be allowed during emergencies to carry out those tasks and duties associated with damage control which are appropriate to their training and normal employment. These duties will have been defined and agreed previously with the contractor.

When an RN/RFA ship or a nuclear submarine is in commission the following procedure will apply:

Upon arrival at an incident involving a RN/RFA vessel the Fire Brigade Incident commander will be met at the brow (Usually marked by a red flag) and escorted directly to the ship's officer responsible for safety in order to receive a full briefing on the fire and be consulted about the appropriate firefighting strategy.

Following consultations with the Fire Brigade incident commander, the ship's officer responsible for safety (known as the Officer of the Day) will decide whether to ask the Fire Brigade to 'stand-by' or alternatively to ask the senior fire officer to undertake firefighting operations.

(b) Command and Control of firefighting operations

If the ship's officer responsible for safety decides that RN/RFA firefighting resources are sufficient to deal with the incident, the Fire Brigade attendance should remain on 'stand-by'. The senior fire officer should remain at HQ1 for liaison and consultation purposes until the Fire Brigade presence is no longer required. The ship's officer will retain control and command of firefighting operations. The Fire Brigade may be asked to provide supplementary assistance, such as facilities for recharging (RN) BA cylinders.

If the ship's officer decides that Fire Brigade assistance is required to extinguish the fire, he will ask the senior Fire Brigade officer to undertake fire fighting operations. At that point, command and control of such operations will be formally delegated to the Senior Fire Brigade officer in attendance. Close and effective liaison should be maintained throughout the period of the incident.

(c) Ship Safety

Notwithstanding the involvement of the Fire Brigade, the RN/RFA Commanding officer or designated representative, retains full overall responsibility for the safety of the ship. The senior fire officer should therefore take full account of any advice received from the ship's officer responsible in respect of ship safety and firefighting tactics, priorities and ship stability. It is important to recognise that the main priority on RN/RFA vessels is ship safety, and that during the initial consultations between the Fire Brigade and the Ship's Officer responsible for Safety a decision might have to be made as to whether search and rescue operations are required in preference to firefighting actions. The need to ensure continuity in firefighting operations throughout the incident is stressed.

(d) Communications

It is essential that effective communications are established and maintained between fire control (quayside), HQ1 and the forward control point (FCP) throughout the period of the incident. The Fire Brigade will normally use their own communications systems, but these may prove inadequate in a warship environment and, in some cases, the associated RADHAZ prohibits their use. Wherever possible, both the Fire Brigade and RN/RFA should appoint a liaison officer to be present at the other service's control point.

(e) Route to the fire

Once the appropriate route to the scene of the fire from the 'ON' brow has been agreed between the ship's officer and the Fire Brigade officer, the ship's personnel will identify the route by running a combined guide and communications line.

(f) Control of personnel

Fire Brigade personnel will at all times act under the direction of the senior fire officer. Likewise, RN/RFA personnel will act under the direction of the ship's officer of the day/duty deck officer. In circumstances where the senior fire officer is in control of firefighting operations, any use of RN/RFA personnel (e.g. to act as guide to Fire Brigade teams) will be by agreement with the ship's officer. In such circumstances, the senior fire officer will be responsible for the health and safety of personnel involved in fire fighting operations.

(g) Withdrawal of personnel

If the Fire Brigade is delegated the task of finding and fighting the fire, RN/RFA personnel will be gradually withdrawn from within the smoke boundary as they are replaced by Fire Brigade personnel. Ship's firefighters, working in pairs and wearing BA, will normally be required to act as guides. Close collaboration between the officer/senior rating in charge of the ship's main group and the Fire Brigade officer at the FCP is essential.

(h) Electrical supplies

The Fire Brigade normally expect all electrical supplies to an installation on fire to be isolated. **This is seldom practicable in a warship fire.** However, when there is a risk of voltages in excess of 440 the equipment should be isolated. It must be noted that attempts at maintaining a 'keep alive' policy may be counter productive when compared with the savings in damage through quick extinction of the fire.

(i) Use of Breathing Apparatus and Control

Ship's staff BA controllers should continue to control ship's personnel using BA, at the same time maintaining the closest possible liaison with the Fire Brigade. Should the firefighting measures be assigned to the Fire Brigade, overall co-ordination of all BA wearers is to be exercised by the Fire Brigade incident commander of firefighting operations. It should be noted that in RN and RFA procedures a smoke boundary is defined, and BA dressing (start-up) will be as close as possible to this point, whether or not this is above or below deck.

(j) Features affecting firefighting operations

Firefighters should note that the lightweight alloy metals used extensively in the superstructure of RN ships will fail quickly in fires and that bulkheads employing them may therefore not act as effective barriers. (The *Manual*, Part 6c, discusses metal fires in general). Other hazards on board RN vessels are the extensive and complex electrical installations, the very heavy smoke-logging which may be experienced – e.g. when unprotected butyl-covered electrical installations become involved in a fire and, of course, the magazines, weapon storage areas and fuel tanks. The absence of port-holes on RN ships may cause problems in ventilation or getting water onto the ship.

Although RN ships have these special hazards, firefighters are helped by other features, e.g. the extensive division into watertight compartments by transverse and longitudinal bulkheads and watertight hatches, and the relatively small amount of flammable material (other than in the stores and magazines). Naval ships have, in addition, more comprehensive firefighting equipment aboard than other ships, and a larger complement of personnel (though whether all are present will of course depend on the circumstances). The fire main pressure in naval ships is usually 5.2 bar on the older types and 7 bar on the newer. Instantaneous couplings on board RN ships are identical with those of British fire services. Smoke boundaries are established by RN and RFA personnel close to the fire. Doors and hatches are designed to contain the smoke and in order that hose lines may be brought to the scene of the fire without the need to open the doors, through bulkhead hose fittings are sited adjacent to each door or hatch. Smoke boundaries once established may not be broken without the express permission of the Officer-of-the-Day.

Magazines usually have a sprinkler system operating from the fire main. Ships which carry aircraft have particularly extensive sprinkler systems in the hangars. Firefighters should be aware of the characteristics of aviation fuel that might be carried.

(k) Firefighting

Firefighting tactics will be determined by a dynamic risk assessment.

An important consideration, as always, will be to keep the amount of water used to a minimum. If the fire is well established, it will of course be necessary to mount a direct attack on it in the normal way. If this is done, firefighters should check that all surrounding bulkheads, decks and hatches are intact, and should cool them with water spray to ensure that they remain so (boundary cooling). It should be noted that checking the fire boundary of an RN ship constructed of GRP (glass reinforced plastic), may be difficult as very little heat is transferred and the wrong impression may be gained.

It may be valuable to inject a firefighting medium other than water into a compartment to hasten the extinction process, and special equipment may be available for this purpose on some ships. Firefighters should always seek the advice of the ship's officers in such circumstances. The length of time before opening up will become possible will depend on the size of the compartment and the intensity of the fire. Firefighters entering the compartment should remember that the atmosphere will be oxygen-deficient.

(l) Nuclear submarines

- UNDER CONSTRUCTION OR REPAIR

As soon as the nuclear reactor has been installed, RN personnel will be present, and the fire brigade officer will need to liaise closely with the ship's officers who are the ultimate experts in the safety of this source of energy on board the ship.

- IN SERVICE

In all probability the nuclear submarine's own firefighting personnel will tackle any fire aboard the vessel. However, there may be occasions when local authority fire brigade personnel will be asked to assist, and in line with the advice given earlier on 'Responsibilities', should tackle the fire accordingly. The Fire brigade incident commander should mobilise the brigade's own radiation checking equipment as a precaution.

5.13 Bulk Chemical Carriers

(a) General

As described in Chapter 1, Section 7 (a), these vessels, despite stringent international regulations, present problems to the Fire Service not only from possible fires but also from spillages, interaction of cargoes, gas clouds etc. The introduction, by mistake, of a chemical incompatible with a tank lining, the inadequate separation of mutually incompatible chemicals, the breakdown of a tank lining, or the failure of piping, pumps, tank walls or bulkheads are examples of conditions which could lead to highly dangerous incidents. There could be a need for local specialist reinforcement to a brigade's chemical data retrieval system, as it is the results of the mixing and interaction, plus possible fire, which will need to be tackled correctly. For example, tanks often need 'washing-out' and it is not unknown for the 'washings' to react. Methanol is one substance used as a 'washer' and is flammable and highly toxic; it is, therefore, a hazard in itself, even if it does not react with the contents of a tank.

As part of the preplanning arrangements, it may be worthwhile to set up a system whereby the brigade is notified of the arrivals and departures of these vessels, with details of their cargoes, especially where 'parcel' tankers are concerned. This information would be made available to the commander of the first attendance to an incident, to enable him to have knowledge of the possible problems to be considered and assist in making the initial risk assessment.

(b) Dealing with an incident

The immediate necessity, after any rescues have been carried out, will often be to protect the undamaged portion of the ship and the dockside risk. The Master may have got his foam monitors, water spray systems etc. into action but much will depend on the competence of the crew, the reliability of the equipment and whether damage to the systems has left them ineffective.

Depending on the size of the incident it may be necessary to wait to accumulate enough suitable extinguishing agent before making an assault on the fire. If water is an unsuitable agent, firefighters will have to take care when cooling down round the area involved (Photo. 5.11).

Even in the open air, BA may still be necessary, perhaps with protective clothing, followed by decontamination. IMO requires that access to various parts of a ship be adequate for firefighters wearing BA sets, not only for firefighting but also for rescue (see Chapter 1 Section 7).

Firefighters must remember that on a ship, but especially on chemical and gas carriers, any small enclosed area, merely by its position, could be oxygen deficient or contain toxic fumes. BA should be worn anywhere personnel have to make a difficult or restricted entrance in order to search or check for fire spread.

(c) Gas clouds

Occasionally, a brigade may be faced with an incident involving the leakage of a toxic or flammable

Photo. 5.11 Fire involving ship's superstructure.
(Humberside Fire Brigade)

gas or vapour. (Photo's 5.12 and 5.13) Whether the resulting cloud is visible or not will depend on its ingredients and the weather. Preplanning should have taken this contingency into consideration and arrangements for evacuation, movement of shipping, monitoring equipment (e.g. gas testing instruments), emergency shut-down of heating systems etc. should be put in hand by the appropriate authorities as soon as possible. The infinite number of conditions possible at such an incident forces planning to be very flexible. The incident commander must try to keep personnel out of the gas cloud, insofar as he can ascertain its extent. Firefighters should if possible keep upwind. If, for the purposes of rescue, an entry into a gas cloud must be made, it should be by as few firefighters as possible, and they should spend only as much time in the danger area as it takes to perform the rescue. They should be warned against operating any electrical equipment, including radio, and, if lights are necessary, they must switch them on before entering the cloud and switch them off only after leaving it.

5.14 Gas Carriers

(a) General

The range of gases that can be carried by these vessels is very wide. The cargo tanks are pressurised and/or refrigerated, often to a very low temperature (see Chapter 1, Section 7 (b)). In order

Photo. 5.12
Shows result of hold explosion.
(Humberside Fire Brigade)

Photo. 5.13
View looking aft.
(Humberside Fire Brigade)

to facilitate unloading, the gases are often heated. Additional heat from a fire can cause problems with a possible discharge of gas through relief valves, with the possible formation of an explosive mixture. Polyurethane foam (usually encased in metal) is widely used as tank insulation (this material has resulted in some disastrous land-based fires in recent years); the possibility of its breakdown and consequent production of high temperatures and toxic gases under fire conditions should be taken into account.

(b) Firefighting

Depending on the nature of the fire/explosion the Master should, if possible, have operated some or all of the shipboard fire protection systems. The first job of the brigade will be to cool the unprotected areas while the Master attempts to shut down cargo pumps etc. Because of the tank configurations on these vessels, many of them have a poor ballast capacity and therefore their stability can easily be upset. The liaison between the various organisations needs to be particularly close to keep the ship stable.

5.15 Fires in Parts of a Ship

(a) Fires in stores

Storage areas found on ships will include paint lockers (often protected by fixed installations), rope stores, deck and engine room stores, linen lockers (frequent source of fire), food stores, and stewards' stores. Even a small fire in a store can give off quite a lot of smoke because of the materials present, e.g. plastics.

Firefighters should make an attack at close quarters with a spray/jet, or possibly high expansion foam. It may be necessary to wear BA.

The engineer's store and workshop, usually located in the engine room, can present special problems due to the clutter of oily material, Fires in these areas are hard to fight and it is important to tackle them as quickly as possible to avoid serious damage to the machinery and cabins above. (See (b) below for machinery space fires in general.)

(b) Fires in machinery spaces

One of the main causes of fire in a machinery space is the leakage or accidental release of oil. For example, a pressurised oil-pipe may split causing fine droplets of oil to be sprayed onto a hot manifold which the ignites with a rapid build-up of heat and smoke. Usually, if the fire is serious enough, the Master will stop all machinery, evacuate engine room staff, close the doors, and operate a CO_2 or foam system. This procedure often means, however, that all powered systems, including fire pumps, are closed down. However, the pump powered from the emergency generator may still be available. If not, firefighters would have to take their own pumps aboard or pump from the dockside.

A major problem with this type of fire is the difficulty for firefighters to gain access to machinery spaces via ladders and platforms (Photo's 5.14, 5.15 and 5.16.). They must never use engine room lifts to reach the area. The normal means of access are, the engine room ladder, the boiler room ladder, the shaft tunnel and the escape ladder (aft accommodation ships).

Any close-fitting doors may have warped in the heat, and it may be necessary to use hydraulic spreaders, rams or toe-jacks to open them. It may also be necessary to cut holes in bulkheads. Personnel and equipment must be kept clear of air intakes where machinery is running.

BA will always be necessary, with the emphasis on controls and guide lines. In some circumstances the fire can result in a serious risk from radiated and conducted heat. It may produce extremely hot working conditions. The incident commander must be especially careful to protect personnel from heat exhaustion; a very low limit on working time may be necessary. When large scale cooling operations are called for, firefighters must have regard to the question of stability; the use of spray and variable nozzles will help.

Boiler room fires, in particular, are hot and difficult to contend with. Fine judgement is necessary, especially in deciding when to ventilate. In all machinery space fires it is necessary to keep a

Photo. 5.14
Shows engine shaft.

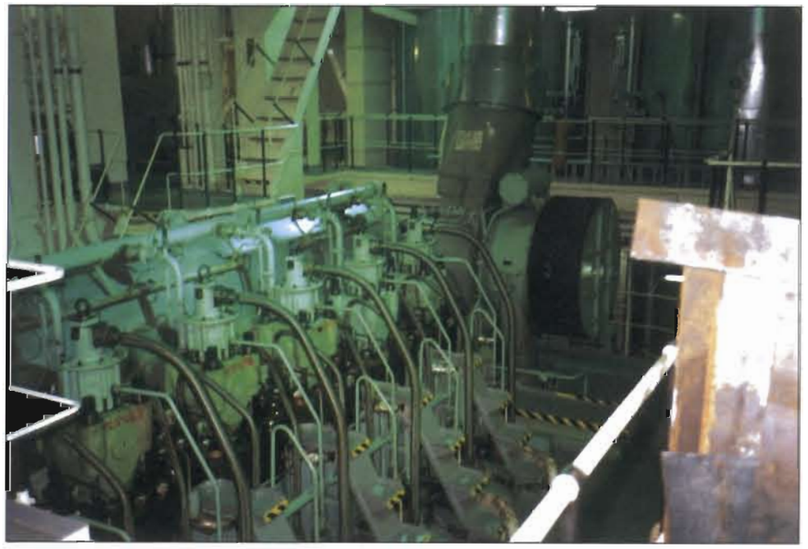


Photo. 5.15
Shows part of engine.

check on adjoining compartments: materials on the other side of bulkheads can ignite very easily. Painted surfaces, too, rapidly assist fire spread. Re-ignition is another major risk in machinery spaces because of the numerous hot areas with which oil can come into contact. Caution is therefore necessary even when the fire is apparently out.

In fighting the fire, firefighters must heed any advice given by the ship's engineer. To prevent the fire from spreading, the oil supply should be shut off if at all possible. As far as firefighting conditions allow, cold jets should not be played on hot pipes or the fronts of boilers and their gauge glasses to avoid fractures. Various methods are available for firefighters to extinguish the fire (see below), apart from any fixed installations. The manual options are discussed as follows:

Photo. 5.16
Shows other equipment in machinery space.

● CARBON DIOXIDE AND INERT GAS

The use of carbon dioxide or inert gas (unless part of the ship's own fire defence) will be difficult to mobilise quickly enough to make an early attack on the fire. However, where installed, (and if not already actuated by the ship's officers) this medium could be used and may save firefighters a lot of unnecessary punishment. Whilst both media have no cooling effect they do however, have the advantage of not seriously damaging machinery and electrical equipment. After operation of the system it would be necessary to monitor heat levels of the enclosing bulkheads and decks over several hours to determine the effectiveness or otherwise of the operation. At some time it will be necessary for firefighters wearing BA to inspect the area to ensure complete extinction.

● FOAM

Medium expansion foam is one option which could be applied with a reasonable chance of success providing it can reach the affected area. The numerous obstructions found in machinery spaces requires the foam to be reasonably slack so that it will flow over and round obstacles to reach the common oil surface.

High Expansion Foam is another option, but again there might be a problem (because of the lightness of the foam) in getting the foam to the area involved. In a developing fire the heated convection currents will act against the foam reaching the fire area.

The fire may have been tackled by the ship's fire party before the arrival of the Brigade, using foam, AFFF or water spray from a fixed installation. Firefighters should consider using the same medium as further topping up or continuation rather than any change of strategy. It may be necessary to vary the foam ratios if it becomes evident that the foam is not reaching the fire area.

● WATER

The use of water spray branches is often the most effective. Turning several spray/jets into the engine casing above the machinery space has a considerable cooling effect and creates a blanket of steam. The up-draught is lessened and the vaporisation rate of the oil reduced, so that a closer attack with branches becomes possible. Water spray is particularly useful for cooling when there is a thin layer of unfired oil in contact with hot plates (e.g. on the top of a tank), since, otherwise, radiant or conducted heat might fire the oil. The value of diffuser branches is, however, reduced where intervening pipework inhibits their full use.

● SELF SMOTHERING

If the application of extinguishing media is not practicable, firefighters may be able to starve the fire of oxygen by closing all openings into the

machinery space. This will usually, however, only be possible on a very small ship: engineering advice should be taken on the practicalities and the best methods.

(c) Fires in up-takes

Up-take fires usually involve the combustion of unburned carbon deposits. They can be difficult to deal with and it is usually better to allow them to burn out whilst providing cooling spray at the appropriate points. Opening the up-takes to gain access can aggravate the situation by increasing the draught.

(d) Fires in the shaft tunnel

The shaft tunnel is often used for the storage of paints, oils, gas cylinders etc., and these may become involved in a fire. If a fire does occur and for any reason its seat cannot be reached, it may be possible to close the watertight door between the tunnel and the engine room (see Chapter 1, Section 1.2 (d) (3)) and flood the tunnel.

(e) Bilge fires

These are very smoky due to the presence of oil residue, and are difficult to detect but relatively easy to extinguish. The application of water-fog or High Expansion Foam through the hatches is usually effective.

Chapter 6 – Incidents at Sea

6.1 Legal Position

(a) Fire authorities

The Fire Services Act 1947 was amended by section 4 of the Merchant Shipping and Maritime Security Act 1997. The amendment adds to the supplementary powers of fire authorities contained in Section 3 of The Fire Services Act 1947 by the addition sub-section (dd) which gives fire authorities power "to employ its fire brigade maintained by them, or use any equipment so maintained, at sea (whether or not within the territorial sea of the United Kingdom)".

While the duty of a fire authority to make provision for fire fighting purposes relates to the authority's own area (see Chapter 3, Section 1 (a)), there is nothing to prevent a fire authority employing its fire brigade to tackle a fire in a ship at sea outside that area.

Each fire authority, either individually, or jointly with neighbouring brigades, will, having considered the implications of section 1 (1) (a) of the 1947 Fire Services Act, and, section 3 (1) (dd) (the amendment under the Merchant Shipping and Maritime Security Act 1997) of the same Act, and determined the extent to which its brigade should undertake firefighting and rescue operations at sea. Participation of individual firefighters in operational incidents at sea is generally carried out on a voluntary basis, but some prior commitment is usually necessary to establish off-shore contingency personnel strength.

(b) H.M. Coastguard

H.M. Coastguard has the statutory duty under the Coastguard Act 1925 by Order of the Secretary of State for Transport, laid before parliament on 9th March 1992 for "the initiation and co-ordination of civil maritime Search and Rescue (SAR) within the United Kingdom Search and Rescue Region" (UKSRR). This includes the mobilisation, organisation and tasking of adequate resources to respond to persons either in distress at sea, or to persons at risk of injury or death on the cliffs or shoreline of the United Kingdom. It follows, therefore, that HM Coastguard is the authority responsible for the initiation and co-ordination of firefighting and rescue at sea.

A 'Memorandum of Understanding' was jointly agreed between HM Coastguard and local Fire Authorities in 1994 to establish, where appropriate, firefighting, chemical hazard, and rescue teams as 'Declared Facilities for Search and Rescue' (SAR). Any such arrangements which generally prevail between the Maritime and Coastguard Agency (MCA) and Fire Authorities do not form any contractual relationship and the MCA should liaise with individual Fire Authorities to establish the extent to which the arrangements contained in the 'Memorandum of Understanding' are to apply.

'Declared Facilities' are facilities which are designated as being available for civil maritime SAR according to a specific standard or set criteria. Each fire authority declaring facilities is responsible for:

- Declaring the standard of capability and availability for each facility;
- Maintaining each facility to the declared standard;
- Informing HM Coastguard when there is any change in the declared standard of availability;

- Informing HM Coastguard of any reason for not making available any facility which is declared and which has been requested by HM Coastguard.

The Coastguard organisation in the United Kingdom is divided into five regions, in which are located six Maritime Rescue Co-ordination Centres (MRCC's) and fifteen Maritime Rescue Sub Centres (MRSC's) each with a constantly manned operations room. There are about 600 regular Coastguard officers assisted by about 3500 auxiliaries. Liaison is best made through one of the six MRCC's.

6.2 Contingency Plans

(a) General considerations

The potential for a major incident even in the smaller ports and harbours and off-shore appears to be increasing. The number and size of potentially dangerous cargoes entering and leaving ports have risen and there have been several instances of passenger ferries being involved in fire. There must therefore be pre-planning for such emergencies.

Where fire brigades have agreed to respond to incidents on ships at sea, contingency plans must be drawn up in consultation with other services, e.g. Coastguard, Harbour Authority, County Emergency Planning officer, police, RNLI, tug companies, armed forces. Where two or more authorities have a common estuary it may be necessary to set up a joint committee to co-ordinate planning and response.

Such pre-planning should consider the following points:

- methods of raising the alarm and alerting essential services,
- efficiency of inter-service liaison arrangements,
- establishment of controls and communications,
- initial reconnaissance arrangements,
- availability of helicopters and water craft, including firefighting tugs,
- rescue and casualty handling,
- facilities for alerting all marine risks,
- control of shipping movements, closure of port, moving endangered vessels,
- risk assessment including identification of dangerous substances,
- predetermined embarkation and disembarkation points,
- types of equipment to be transported to the scene,
- minimum number of personnel/officers required including relief crews,
- provision of predetermined beaching points,
- catering arrangements,
- attendance of interpreters where there are language difficulties,
- Information to be obtained on receipt of call should include:
  - location of vessel,
  - abandoned or crewed (if crewed – nationality),
  - number of people on board,
  - type and size of vessel,
  - cargo carried,
  - nature and extent of fire,
  - weather and sea state.

Depending on local circumstances, there may be a need to set up a land-based incident control where the organisations involved can liaise and co-ordinate operations, this is likely to be at the nearest Coastguard Rescue Centre. It is also quite common for a forward control to be set up, either on the vessel on fire, or a firefighting tug attending the incident.

(b) Notification of incidents

The fact that the Master of a vessel reports a fire, explosion or other emergency at sea does not necessarily mean that he requires assistance. He may decide to tackle the cause of the emergency himself, bearing in mind the possibility of salvage claims (see Chapter 3, Section 6). Fire authorities will make their own arrangements locally with the Coastguard as to what is reported to them and how, but should ensure that their assistance has been expressly requested by the owners, agents or Master before attending the incident. Also, when the commander of the first attendance, or reconnaissance, arrives, he should confirm with the ship's Master that the assistance of the brigade is still required. If the Master has requested help from the brigade, he should obviously co-operate and listen to advice from the incident commander.

(c) Sea transport

Regardless of the mode of transport used for initial attendance (or reconnaissance), whether by sea or air, arrangements should be made to have a vessel standing by for safety purposes throughout the incident. Ideally a vessel used to transport personnel or equipment to the vessel in distress should remain on standby at the incident in case rapid evacuation without helicopter assistance is required, or a firefighter falls overboard. If that vessel cannot remain on station at the incident, then arrangements must be made for another vessel to stand by for safety purposes.

Part of pre-planning will be to establish what vessels could be made available as transport for fire brigade personnel and their equipment. Whatever craft are employed they must be readily available, seaworthy, relatively easy to bring alongside a ship to load and unload, and capable of carrying the necessary load safely.

Some brigades have developed pre-packaged equipment, using pallets or boxes which can be quickly transported to the quayside for loading onto the transporting vessel. Consideration would need to be given as how the equipment is loaded onto the transport vessel and subsequently onto the incident ship if that is required. On very small vessels, firefighters should take into account that lifting equipment from the quayside, or from vessel to vessel, by on-board tackle could have an effect on the lifting vessel's stability. (See Chapter 4)

All fire brigade personnel should wear lifejackets on the transport vessel.

(d) Air transport

The availability, capability and range of SAR helicopters, RAF mountain rescue team helicopters, or helicopter belonging to private companies in the sea area adjacent to a brigade would need to be established (Photo's 6.2 and 6.3). Some brigades have already made the necessary enquires and set up arrangements to transport men and equipment to vessels at sea. It is important that the weight of equipment likely to be required is known before the event as the aircraft captain will need this information to decide how many firefighters and what equipment can be transported at one time (Figure 6.1).

Personnel who are likely to be taken to ships at sea via this mode of transport will need to be trained in the safety procedures associated with helicopter flying before any actual flying is undertaken.

Photo. 6.1
Ocean going tug.
(HMFSI)

Operational Procedure Sea King Aircraft

		Totals
DROP 1		
Initial Individual Drops		
4 x personnel c.w Radio Pack set	370 kg.	370 kg
DROP 2		
No. 1 Container		
4 x 25 m x 45 mm hose		
1 Dividing Breeching (alloy)		
2 Variable Branches (AWG type)		
1 Suction Strainer (alloy)		
1 First Aid Kit		
2 Handlamps		
1 Ships Adaptor F1 to N and S fitting		
Food, water, sea sickness tablets		50 kg
DROP 3		
No. 2 Container		
1 BA set c.w. 1800 litre cylinder	21 kg.	
2 BA cylinders (1800 litre)	29 kg.	
1 BA servicing kit comprising -		
'0' ring washers		
anti-dim		
disinfectant		
cloths		
D.S.U. key		
24 torch batteries		
Bardic torch key	3.5 kg.	
1 BA entry board	1.2 kg.	
		54.7 kg
DROP 4		
No. 3 Container		
1 BA set cw 1800 litre cylinder	21 kg.	
2 BA cylinders (1800 litre)	29 kg.	
1 x 30 m GP line	6. 4 kg.	
2 handlamps	1. 6 kg.	
2 axes (small)	2. 6 kg.	
		606 kg
DROP 5		
LPP pump cw slings, suction wrenches, etc.		180 kg
DROP 6		
3 x 3 m x 100 mm suction hose (alloy)	54. 5 kg.	
1 x GP line 15 mm	3. 2 kg.	
Petrol 1 x 18 litre	19 kg.	
		76.7 kg
Overall Total Weight		
TOTAL		792 kg

Figure 6.1 An example of preplanning to carry equipment out to a ship by helicopter.

(e) Communications

Experiences by brigades who have undertaken firefighting operations at sea have shown that, unless there is very detailed pre-planning, communications can be very difficult.

Harbour craft, tugs etc within port operational areas use marine radio channel 16 for emergencies but as this is also a calling channel for all marine craft, communication is subject to interruption. Most brigades find it more efficient to take, as part of their reconnaissance and first attendance equipment, portable pack sets which maintain a separate link either to forward controls on shore or into the brigade network (Photo. 6.4). This ensures that radio discipline is maintained, the channel does not become overloaded and other services are not interrupted. However, brigades main scheme channels must not be used for air-to-ground communications.

Brigades may use mobile or transportable radios using VHF channels 21 and 22, and/or radios using

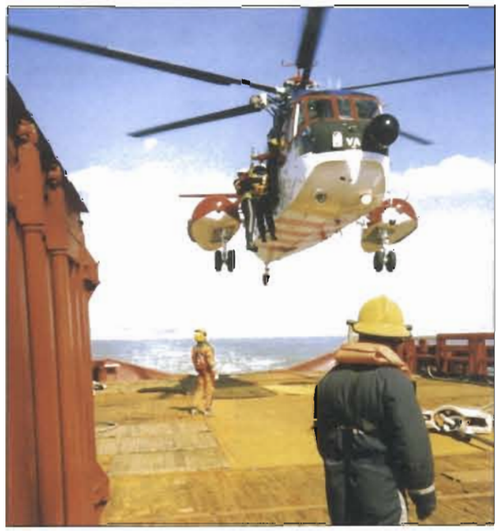


Photo. 6.2 Landing off-shore firefighting crew on casualty. (exercise) (Kent Fire Brigade)

Photo. 6.3 Off-shore firefighting crew aboard RAF rescue helicopter. (Kent Fire Brigade)

Photo. 6.4 Off-shore Communications equipment.
(Kent Fire Brigade)

UHF channels 1 to 6 within UK territorial waters to communicate between vessels.

Cellular phones are licensed as land-based systems, but as there is likely to be some overlap coverage at sea this may be used to access directly the public telephone system. If the off-shore incident is near to other continental shores the mobile phone will need to be such that communications can be through foreign relay stations. The UK prefix and area codes will need to be known.

Brigades should ensure that firefighters learn and understand marine phraseology so that any communication with marine personnel is clearly understood. (Some of the more common terms are explained in the glossary at the end of this Manual.)

(f) Firefighting equipment

Although there may be occasions when it is possible to use the firefighting equipment of the distressed vessel, it is recommended that the fire service should plan always to provide its own equipment for firefighting and rescue operations at sea. This practice has the merits of maintaining the confidence of personnel in the efficiency and reliability of the equipment used. (Photo. 6.5)

- Hose.
- Branches.
- Containers and slings.
- Ship-to-shore connections.
- Wheel spanners.
- Heaving lines.
- BA sets and spare cylinders.
- BA entry control boards, guidelines and tallies.
- BA communicating equipment.
- BA hand lamps.
- BA tabard.
- First aid equipment, for example resuscitation equipment, stretchers.
- General purpose lines.
- Light portable pumps (preferably diesel) and suction hose/strainers with spare fuel.
- Lighting equipment.
- Hand held radios/loud hailers.
- Tools.
- Gas detection equipment.
- Rations and drinking water.
- Thermal image camera.
- Foam concentrate.
- Message pads, pens and chinagraph pencils.
- Nominal roll boards.

Photo. 6.5 Lowering packaged firefighting equipment. *(Kent Fire Brigade)*

Photo. 6.6
Off-shore survival suit.
(Kent Fire Brigade))

It will be apparent that off-shore firefighting operations may have to be undertaken in adverse weather conditions. Particular attention should therefore be paid to appropriate provision being made for the safety and welfare of personnel taking part. Equipment suitable for personnel safety and welfare is listed below.

- Firefighting uniform
- Heat resisting gloves
- Waterproofs
- Survival suits (Photo. 6.6)
- Lifejackets
- First aid equipment
- Sea sickness pills
- Food and drink

6.3 Dealing with the Incident

Most of the problems of firefighting in port will apply at sea, and the basic strategy and tactics (see Chapter 5) should be applied. However, such problems will be compounded by the relative isolation of the firefighting team.

(a) Reconnaissance

Experience has shown that the initial call to a brigade for assistance often does not give sufficient information as to what the situation is or even where it is. If possible, a small reconnaissance group led by a senior officer should be sent out to the stricken vessel. This can be done whilst equipment and personnel are being assembled at embarkation points. During the approach to the vessel it is well worth taking particular note of any points covered below which may not be so obvious once aboard the vessel (Photo. 6.7). Any information noted on the approach, together with situation found on board could be radioed back to brigade. Such information is likely to be invaluable in assessing the necessary response.

Photo. 6.7 Reconnaissance on approach to hovercraft (exercise). *(Kent Fire Brigade)*

The information could include such items as:

- Precise location of the incident.
- Fire situation, e.g. what part(s) of the ship are involved, whether it is spreading.
- Name of the vessel and its owner or agents.
- Type of vessel and tonnage.
- Whether crewed or not.
- Stability situation and amount of freeboard.
- Whether the ship's pumps and firefighting equipment are usable.
- Whether fire tugs could be used.
- What special equipment is required, e.g. HEF, ejector pumps.
- Manpower required – especially for BA.
- Weather situation and sea state.
- Could equipment be air lifted.
- Any problems likely to be encountered in getting alongside stricken vessel to unload men and equipment.

The commander of the reconnaissance group may find that the Master has already taken some steps to control the incident himself, e.g. rigging hose lines, injecting inert gas or other media, ventilating or, conversely, battening down and turning the ventilation off. The incident commander should give careful consideration to why these moves were made before advising to the contrary.

(b) Boarding the ship

This can be problematical in relatively calm weather and very difficult in rough weather. On a very large ship, e.g. a VLCC, the freeboard could be 20–25 metres. Usually an accommodation ladder (Photo. 6.8) will have been lowered in readiness for the brigade to board but occasionally, if the crew have abandoned ship, this may not have been done. If a reconnaissance has been carried out by helicopter and personnel put on board, it may be possible to rig rope ladders and safety lines to help personnel to get onto the ship. The ship's own 'Jacob's ladders', sometimes adjacent to the ship's lifeboats, may be used. On no account should personnel be linked to each other by line, even when mounting the accommodation ladder. This ensures that if one firefighter slips, others are not also dragged down.

Photo. 6.8 Shows accommodation ladder – may be lowered to water level. (Kent Fire Brigade)

It will then be necessary to get equipment aboard. If carried by helicopter, this will be controlled by the air-crew and man-handled by the fire-crew on deck. If the equipment is transported by sea, it may be possible to use the ship's crane or derrick, operated by the ship's crew; otherwise firefighters will have to rig their own tackle for hoisting. Any hoisting of equipment from a transport vessel to a stricken ship is fraught with dangers if either vessel is rolling. Boxes of equipment or pumps could be smashed against the ship's side and damaged or lose the contents of boxes completely. It might be better to abandon this form of transfer than risk the loss of equipment vital to any firefighting.

(c) Pumping

If the ship's fire mains are out of action and there is no fire tug available, the brigade will need to use its own pumps. The amount of freeboard could preclude any lifting of water over the side of the ship, but it may be possible to place a pump on a lower landing of the accommodation ladder or open a loading door lower down the ship's side. Failing this, pumps may have to be set in over the side of the tug or other vessel which has transported the equipment out, and water relayed up to the deck of the stricken ship. This could be reasonably easy in calm weather, but even with only a slight swell running, the task of keeping suctions submerged, engines and electrics dry, and hose lines connected would be difficult. Firefighters must remember that the Master of the ship may want to, or indeed have to, keep under way either to make port or at least maintain his position. This will add to the problems.

(d) Stability

The theory and problems of stability have already been dealt with in Chapter 4 and this will be the same at sea. Close liaison between the Master, the incident commander and his stability officer will be necessary. Due to the possible 'tenderness' of the ship, deteriorating weather conditions etc, the Master may want firefighting to stop. The incident commander will have to abide by this decision until the Master considers it is safe to resume operations.

(e) Breathing apparatus control

The relative isolation of the fire crews can cause problems of supply and not least of these, in a prolonged attack, is the recharging of BA sets. One of the important aspects of pre-planning is ensuring that, once firefighting begins, a continuous attack is sustained. The initial supply of BA cylinders may well be used up in finding the fire and laying guide lines. A rapid build-up of BA supplies may be necessary because worsening weather conditions may seem likely to preclude further supplies or, at least, to delay them. Once on board, the usual main BA control will be set up but the incident commander may think it necessary to have forward controls on each deck of a large vessel. The need for several safety BA crews will have to be taken into account on the reconnaissance when estimating numbers of personnel. When working up and down vertical ladders or steep companionways, BA crews should not be attached to one another by personal lines but should be individually attached to the guide line.

6.4 Salvage Tugs

If the vessel involved has sent a general 'Mayday' signal, the incident commander may find other vessels in attendance when he arrives. It could also happen that other vessels may come alongside whilst the incident commander is aboard without him initially being aware of them. The question of salvage is always present at these incidents, and the brigade could find that another vessel has rigged hoses and brought them aboard the burning ship. If such incidents occur, the incident commander should note the name of the vessel and some details of its actions. It is not unknown for the fire authority to be asked, at a later date, for information on the activities of these vessels, and it would be to the advantage of the incident commander to be able to confirm or deny any allegations. (See Chapter 3 section 6)

6.5 Abandoning, Beaching and coming into port

Incident commanders should remember that the Master of a vessel on fire may also be the owner. Under these circumstances he will obviously take all possible measures to avoid total loss, mitigate damage to his cargo and prevent salvage claims. In doing so he may hazard the ship and the lives of everybody aboard. Even if he is not the owner he may be under instructions from the owners or agents to the same effect. A decision to abandon ship would therefore not be taken lightly, but it may be taken very late and the incident commander must be prepared for it.

Methods of withdrawing personnel quickly from below decks, especially BA wearers, should be set up from the start of firefighting and all firefighters instructed accordingly.

A decision may be made to beach the vessel. There could be a conflict of opinions here between the Master, pilot, harbour Master, tug skipper, agents etc. as to the best location for this. The brigade officer must, however, be ready to point out that to

beach the vessel may result in the firefighting becoming more difficult and may result in a total loss anyway, e.g. where at low tide even fire tugs or fireboats cannot get alongside and land fire appliances cannot approach near enough on shore. Here again the fire authority's arguments and the final decision reached should be recorded by the incident commander, because such evidence may be necessary later.

The Master of the ship may wish to enter port to get the problem resolved, e.g. to unload so as to get access to the cargo involved. The decision as to whether he may enter a particular port, and if so, where he may berth, is the responsibility of the Harbour Master, who will probably make this decision after consultation with the brigade to ensure that,

- any special facilities required are available,
- any isolation necessary is possible, e.g. in a chemical incident, and
- the ship can be berthed in a position readily accessible to the brigade by land and may ask the brigade for its opinion on the possible hazard to the port. This will depend on the type of cargo involved but in most cases it will be advantageous to proceed to a berth, however remote, because of the concentration of personnel and equipment which can be made available there, plus the facilities for moving cargo etc.

If the ship's Master is unable to find a nearby British port which is willing to accept the ship, an attempt may be made to enter a foreign port. If so, the fire officer will have to decide whether firefighters should disembark beforehand or proceed with the ship to its destination. In reaching his decision he should consult the ship's Master and bear in mind the fire situation.

6.6 Sea and Air-Sickness

During training it will become apparent that some personnel are unsuitable for air or sea travel due to sickness, particularly in rough weather. However, fire brigades should consider the issue of travel sickness medication. Even in good weather an air or sea trip can be bumpy, and an issue of this medication before embarkation should lessen the problem for those unfortunate sufferers.

It is worth, at the pre-planning stage to seek medical advice as to which type of sea-sickness medication to issue, as some tend to make the user drowsy. It is also a wise move to issue the medication well before travelling and to continue the dose rate. Some people do not suffer from travel sickness and others may claim not to, but it is a wise practice to encourage the general taking of medical precautions rather than a firefighter become ill when wearing BA and when others are relying on them.

Photo. 6.9
RNLI Lifeboat.
(Essex Fire and Rescue)

Chapter 7 – Dangerous Substances on Ships and in Port Areas

7.1 General

The carriage of dangerous substances by ships is increasing. Apart from fires, there are currently about 300 incidents a year involving dangerous substances on ships and these are mostly normal chemical incidents. There are, however, the added complications of usually quite large quantities, possible mixed cargoes, pollution dangers, decisions on berthing, and movement of tides. Incidents may also occur at port installations during loading, unloading or storage. Brigades will have included such factors in their pre-planning, and should implement the normal routines for dealing with such incidents, bearing in mind the points mentioned in this chapter. (Dangerous goods carried on inland waterways are dealt with in Chapter 8; nuclear submarines are mentioned in Chapter 5.)

(a) Ships

The *Merchant Shipping (Dangerous Goods and Marine Pollutants) Regulations 1997* which are designed to implement the provisions of the SOLAS recommendations, lay down the statutory requirements for the carriage of dangerous goods on UK ships, and on foreign ships that are loading or unloading cargo, passengers or fuel within UK waters. Other relevant documents are the *International Maritime Dangerous Goods (IMDG) Code*, and the IMO Codes relating to dangerous bulk cargoes. The IMDG Code is the most extensive dangerous goods reference available and is applied to all vessels carrying dangerous substances. The information displayed on packages is not restricted to sea trade and will be encountered on the road/rail movement of sea trade. The code identifies those substances which are marine pollutants and every effort must be made to prevent these substances from entering the marine environment. If such an accident happens then the loss of the substance has to be reported. In a fresh water port or river, some cargoes may be environmental pollutants. A new IMO Recommendation on the Safe Transport of Dangerous Cargoes and Related Activities in Port Areas was published in 1995 and will shortly be adopted by new legislation.

(b) Port areas

The IMO recommendations for the transport, handling and storage of dangerous substances in port areas were published in 1995. These will shortly be adopted as statutory requirements for such areas, called the Dangerous Substances in Harbours and Harbour Areas Regulations (DSHR). These are being formulated by the Health and Safety Executive and will replace most of the present local byelaws and regulations. A Code of Practice will be issued at the same time.

7.2 Identification of Hazards

(a) On ships

The Merchant shipping Dangerous Goods Regulations (MSDGR) require the shipper to provide the ship owner or Master with information as to the nature of any dangerous goods to be carried, whether packaged or in bulk. In the case of packaged goods (including those carried in containers, vehicles or portable tanks), such information must include the correct technical name of each substance, the UN number if one exists, the class of hazard, the number and type of packages, and the total quantity of dangerous goods. A ship with packaged dangerous goods on board must carry a manifest or equivalent document stating the name, classification and quantity of each item, and a record of the location of the goods. (An example of such a manifest is shown in Figure 5.1.) In

addition, each individual package, container etc., must be clearly marked with the name of the goods and an indication of the nature of the hazard e.g. a hazard warning diamond. Obviously, firefighters should be able to recognise the marine pollutant mark (Figure 3.2).

In view of the above requirements, the incident commander at an incident on a ship will normally find little or no difficulty in ascertaining details of any dangerous substances from the ship's officers. (If the ship is in port, the port requirements – see below – will operate in addition.) Problems might occur, however, in the case of a call to a foreign ship at sea.

In addition to the basic information required by the MSDGR, there will in some cases be fuller details available, e.g. IMO emergency schedules (see Section 4 below).

Where goods are shipped in road tankers, UKTHIS or ADR labels may be found. Firefighters should remember, however, that the emergency action (Hazchem) code shown on UKTHIS labels is designed for road incidents and may not be appropriate on a ship.

(b) In port areas

The DSHR will normally require the Master of a vessel bringing dangerous goods into a port area to provide the Harbour Master and berth operator, in advance, with information about the nature of the hazard; the proposed Code of Practice recommends that this information should include the name, the substance identification number where available, and the quantity of each item. Where 250kg or more of a dangerous substance, or any quantity of explosives or dangerous bulk goods, is being loaded into or unloaded from a ship, or stored before loading or after unloading, the berth inspector will be required to ensure that information as to the identity, quantity and location of the substance is immediately available to the emergency services. In the case of bulk cargoes, he will also have to include information about the nature of the hazard and the emergency action that should be taken.

It could be advantageous for the brigade to arrange for the port authorities to notify them routinely of the cargoes of all bulk chemical carriers entering or leaving the port

7.3 Segregation of Dangerous Goods

The IMDG Code sets out requirements for the segregation of incompatible dangerous goods from one another, and from other goods such as foodstuffs, on board ship (Figure 5.1). Some of these requirements are based on distance, and others on fire resistant decks and bulkheads.

There are no detailed guidelines for the segregation of goods in the port areas, but the proposed DSHR will contain a general requirement for goods to be stored in a safe manner. Storage areas do not usually have fire-resistant partitions, but do have the space for distance segregation.

7.4 Emergency arrangements by Port Authorities

It will be a requirement for port authorities to make plans for dealing with emergencies under the DSHR, although in all probability this will already have been done. Such plans must include not only the control of the ships carrying the dangerous substances but also the storage and handling etc, the means of escape for people from the berth, methods of communication with the emergency services and effective means of warning people in the vicinity. The plans should be set up in co-operation with the emergency services; further details are given in Chapter 3, Section 3.

7.5 Dealing with the Incident

(a) On ships

Procedures for dealing with a shipping incident involving dangerous substances will closely follow those used at land incidents. Incident commanders should remember that expert advice is available from the CIA (Chemsafe), Department of Transport, NAIR etc, and should consider invoking this part of the contingency plan at an early stage. The IMO publish emergency schedules, giving information to Masters about action to be taken at incidents, and these could be aboard.

The circumstances of these incidents vary considerably, but one important factor to be borne in mind is the possibility of explosion.

Most cargo ships do not have intrinsically safe electrical gear, and any movement of electrically operated hatches, switching of ventilating systems etc could therefore be dangerous if there is a potentially explosive atmosphere present. There are very strict regulations regarding the use of radios near certain types of explosives, and the positioning of appliances, e.g. control units, must be carefully considered under these circumstances. (See Fire Service Manual – Communications)

It may be necessary to monitor a vessel by means of explosimeters. If a brigade does not have these, arrangements may be made to obtain them through the Chemsafe scheme together with personnel trained to use them. Brigades should investigate these and other sources of expertise on 24-hour availability.

Under the MSDGR, UK ships, and foreign ships loading or unloading within UK waters, are subject to certain special safety requirements regarding the stowage of explosives and the type and quantity that may be carried.

(b) In port areas

In addition to the considerations applicable to ships generally, there are several specific points which should be noted in connection with port incidents.

Where vessels carrying dangerous substances are berthed, the berth operator must provide adequate means of escape from the berth, e.g. duplicate gangways to jetty or shore. He should bear in mind the possibility of smoke or fumes, or perhaps burning material on the water, in deciding what provisions to make.

If dangerous conditions exist on a vessel, the numbers of personnel on board should be kept to the minimum. Any passengers should, of course, be evacuated and the main fire-crews kept at readiness on the quayside or as near as is considered safe. According to the proposed DSHR, however, the Master of a vessel carrying certain dangerous substances must have his vessel in a constant state of readiness to move, tidal conditions permitting. For this purpose he is expected to ensure that there is sufficient crew and supervising officers available on board at all times. How this apparent clash of requirements is to be resolved is a further point for discussion in the pre-planning stage.

Pollution of harbour or dock waters is also strictly controlled, and brigade personnel should try to prevent any pollutant entering the water. The Department of Transport have a Marine Pollution Control Unit which is available to provide assistance. It can be contacted, on a 24-hour basis, through any of the Coastguard regional control rooms (see Chapter 3, Section 5).

Chapter 8 – Inland Waterways

8.1 General

Of the estimated 4,800 km of inland waterways in the UK, about 1500 km are used for commercial transport in which some 60 million tonne of assorted goods is estimated to be moved each year. (Photo. 8.1) British Waterways (BW) is UK's largest navigation authority and manages 3,200 km (2000 miles) of canals and inland waterways nationally, including a number of major rivers such as the Severn (Gloucestershire), Ouse (Yorkshire), and Trent (Nottinghamshire). However, much of the commercial tonnage is carried on non-BW waterways controlled by port authorities, local government, or other bodies such as the Environment Agency or the Broads Authority. Nevertheless there are a number of large commercial vessels on BW waterways which can carry up to 700 tonnes; these include for example small cargo coasters (Figure 8.1), self-propelled tank barges (Figure 8.2), small parcel tankers as well as "specials" designed to carry chlorine, caustic soda, sulphuric acid and other bulk cargoes. (Figure 8.3)

The bulk of the craft on inland waterways are the 25,000 or so pleasure craft which range in size from 20 metre narrow boats to 2.5 metre cabin cruisers. Some of these larger powered craft include registered trip boats which can carry hundreds of people at any one time. Unpowered craft such as kayaks and canoes are also found on the canals and these too will have their range of associated hazards.

Photo. 8.1 Commercial vessel on waterways. *(Courtesy of British Waterways Photolibrary)*

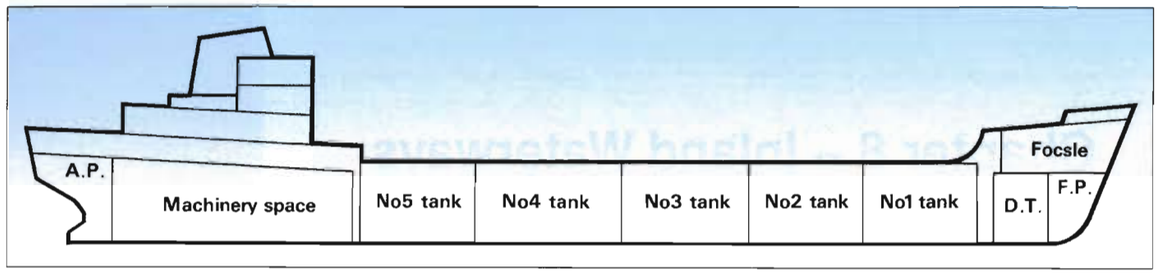


Figure 8.1 Coastal tanker of about 3.000 tonne dwt used to come alongside riparian oil product depots.

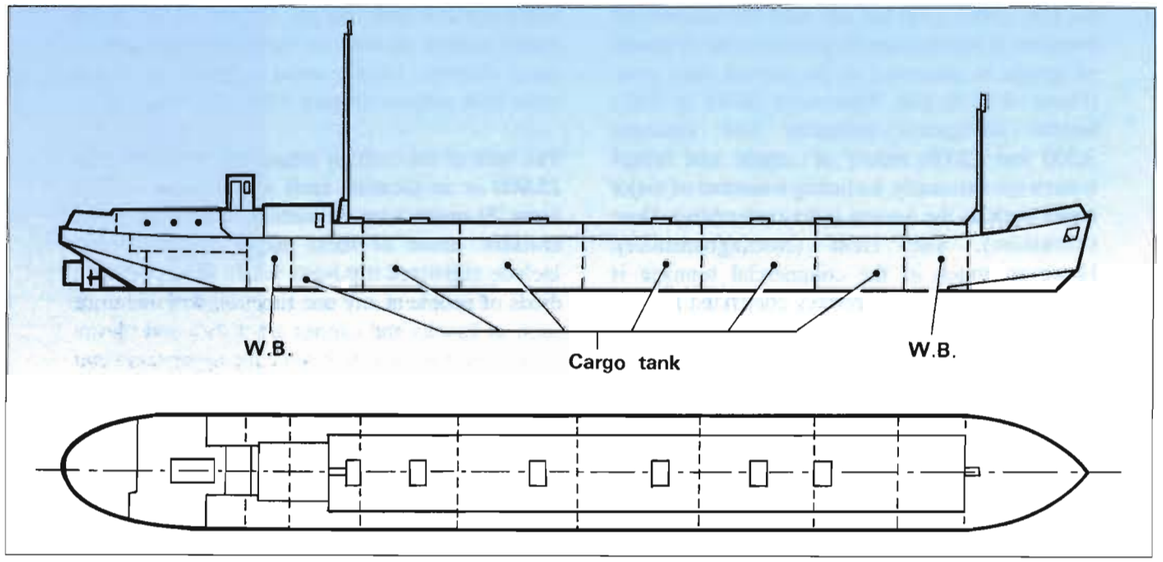


Figure 8.2 Example of inland waterways tank barge of about 380 tonne with cargo capacity of 780 m³.

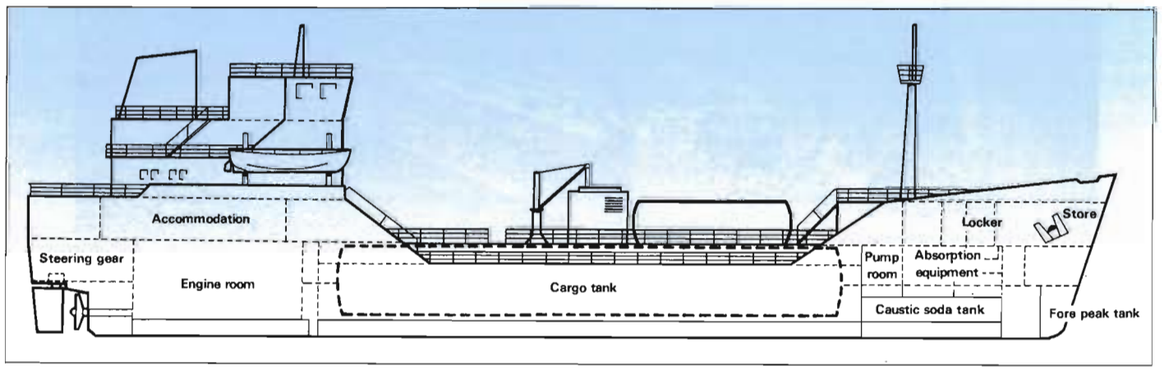


Figure 8.3 Small gas carrier carrying a regular load of liquid chlorine.

8.2 Dangerous Substances

(a) Legislation

Control of the carriage, handling and storage of hazardous cargoes within waterway areas is mainly covered by the *Dangerous Substances in Harbours DHSA) Act 1987* and the *Petroleum (Consolidation) Act 1928*. The *International Maritime Dangerous Goods (IMDG) Code* applies to sea-going vessels which use inland waterways, while the road transport of goods from ports and docks fall under road traffic legislation such as the *Road Traffic (carriage of Dangerous Substances in Packages etc.) Regulations 1992* and the *Road Traffic (Training of Drivers Carrying Dangerous Goods) Regulations 1992*.

(b) Identification of hazards

On the larger rivers, particularly in the North East, substances such as coal, caustic soda, fertiliser containing ammonium nitrate, metal scrap and grain is carried on a regular basis. BW must be notified in advance, in accordance with DHSA, of any intention to transport dangerous goods on its waterways or to bring them onto its premises. Such goods will be accompanied by written information providing details of the properties of the materials being transported and stating the appropriate precautions and emergency action to be taken (Figure 8.4). Any relevant details of bulk goods being carried is obtainable from either the pilot of the vessel or from BW. Packages and small containers will normally be labelled to indicate both the identity of the goods and the nature of the hazard in accordance with various legislation such as the *Chemicals (Hazard Information and Packaging for Supply) Regulations 1994*.

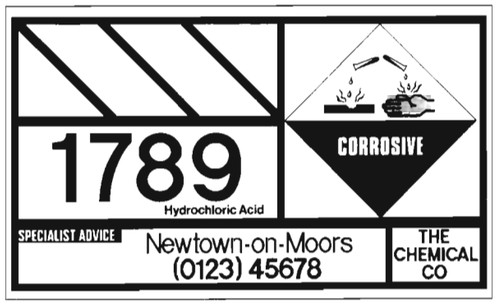


Figure 8.4 British Waterways Board adaption of the Hazchem Code land transport sign to their vessels carrying dangerous goods.

8.3 Other Hazards

The number of non-petroleum hazardous cargoes carried on canals is relatively small and these will mainly be found within the port and dock areas. Narrow-boats are largely steel hulled and other smaller powered craft can be constructed of GRP. However, it should be noted that most pleasure craft will have one or more LPG cylinders aboard and this coupled with relatively light construction, plastic foam furnishing and in many cases petrol as the fuel, will result quite often in a fierce fire. The risks involved are often further exacerbated by the congregation of these vessels together in relatively confined spaces such as marinas. (See also Chapter 9, Section 1.) (See Photo. 8.2)

There is not much flow in a canal and any spillage of flammable substances e.g. petrol, will therefore remain close to the affected craft. In a river however, the dispersion downstream may be rapid and

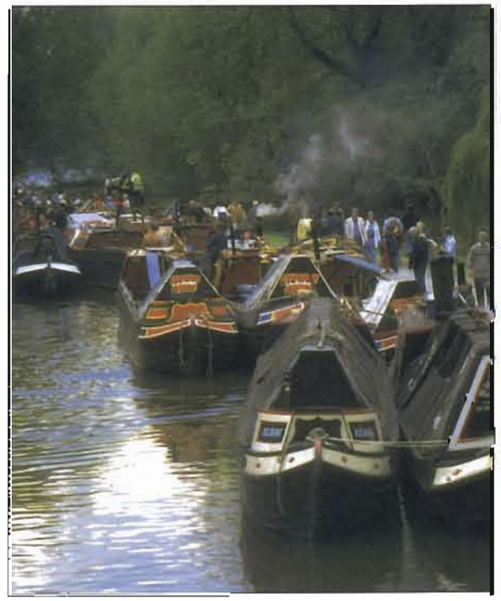


Photo. 8.2 Pleasure narrow boats.
(Courtesy of British Waterways Photolibrary)

some fire cover will need to be deployed in that direction. Firefighters should also bear in mind the danger of pollution, and any such incidents should be reported immediately to the Environmental Agency in the case of rivers or the local Environmental Health department for canals.

The narrow corridors of canals and rivers may prove to be difficult for gaining access via the towing path in some areas. Brigades should familiarise themselves with the waterways in their area and establish alternative routes wherever necessary.

Emergency action plans are being drawn up for all BW tunnels and Brigades should liaise with local BW staff to finalise their local arrangements.

The following list, which is by no means exhaustive, of the types of other problems that may be encountered when firefighters are called to an incident on an inland waterway:

- difficult/remote vehicular access;
- strong currents/fast flowing waters e.g. weirs, rivers etc.;
- overhead electric lines;
- contact with other electrical or hydraulic hazards;
- flooding;
- storm damage;
- structural failure of the waterway infrastructure e.g., breach of the bank;
- stranded, grounded or sinking vessels;
- confined spaces e.g., lock chambers etc.
- lack of adequate headroom e.g. low bridges;
- traffic congestion e.g. at bridges, locks etc.

8.4 Brigade procedures

Both the commercial and leisure use of inland waterways is increasing and therefore incidents are likely to become more frequent. All aspects of firefighting and rescue will need to be considered, for example in many cases casualties may need to be hauled up a retaining wall (e.g., lock chamber etc.). It is important that firefighters make themselves familiar with the following in their area:

- the volume and type of water-borne traffic;
- the type of hazardous bulk and packaged goods being carried on a regular basis;
- the layout of wharf, port and dock areas;
- the location and operation of locks, weirs and major bridges;
- local mooring facilities;
- marinas, hire boat bases and trip boat operators;
- means of access to waterway tunnels;
- towing path access points.

Because of the variance in areas of controlling authorities there may be different arrangements for conveying dangerous goods, calling the brigade, transferring of cargoes, storage and transport etc. Brigades should establish contacts with such authorities and visit wharves and dock areas, vessels and liaise with the owners, harbourmasters and berthing agents to pre-plan for any emergencies. BW have their own emergency action plans in place and these will have been consulted with local brigades. It may be appropriate in some cases to carry out table top emergency exercises in conjunction with those parties likely to be involves in an incident e.g. BW, local authorities, dock and harbour authorities, Environmental Agency etc.

Chapter 9 – Other Marine Risks

Whilst ships, ports, docks and inland waters represent the larger commercial risks to which firefighters are likely to be called, there are other water-borne risks associated with coasts, rivers and lakes which are worthy of consideration in this part of the Manual.

9.1 Yachts, Marinas and Boat Yards

In the past 30 years there has been a tremendous growth in the number of people messing about in boats. During this period the number and size of both sailing yachts and motor cruisers has increased. The majority of boats are constructed of glass fibre but steel and timber are still to be found. The development of the marina has enabled this growing number of boat owners to find a sheltered berth with easy access to popular sailing areas.

The number of incidents involving fire on yachts or motor cruisers has not been great but there is the potential for a larger problem where a lot of boats are either moored close together when afloat, or laid-up ashore during the winter months (Photo. 9.1). The construction material and contents of most boats are very combustible and once involved in fire will burn fiercely.

When afloat yachts and boats will be moored either

- In a marina, occupying a single berth, or sharing a berth (alongside another boat).
- Moored away from the shore, on a swinging mooring or moored between mooring piles or buoys.
- Alongside a quay, singly or with several other boats alongside.

Photo. 9.1
Yachts at risk by congestion.
(A. Mechen)

Photo. 9.2
Marina main walkway pontoon, with finger pontoons off.

When moored away from the shore there is an obvious access problem for firefighters. Brigades will need to make prior arrangements with harbour masters, marina managers, or boat yards to have access to a boat suitable to transport firefighters with their equipment to a boat on fire. It is assumed that such arrangements would only cater for boats less than a quarter of a mile away from the starting point, all being in sheltered waters. For situations other than described here the relevance of the information contained in Chapter 6 – Incidents at Sea – should be considered. Care should be taken to ensure that the boat to be used is safe for use in all weather conditions and that where appropriate alternative means of propulsion is available (pair of oars or paddles). Ideally a boatman who regularly uses the boat is the best person to take a crew out to an incident.

The means to extinguish the fire will involve either a light pump or hand extinguishers. The light pump should be operated from the boat used for transport which should remain ready for a quick withdrawal should this become necessary.

The yacht or boat on fire may sink on its moorings for a number of reasons other than being filled with water by firefighters, or it may burn through the mooring ropes and become a drifting risk to other moored vessels.

Yachts or boats in a marina or alongside quays are relatively easy to tackle in comparison to away from shore situations, but nevertheless could become a similar problem if the mooring lines become involved in the fire, or the boat yard/marina management decide to move the boat away from other boats.

Pontoons or walkways serving marinas vary in design, most are reasonably substantial but care may be needed in some situations, particularly on pontoons serving 'finger berths' off the main walkways which are usually narrower and more 'tender' than the main walkways. (Photo. 9.2)

A hose reel is usually available to reach each berth in a marina to enable the boat to fill its water tank. This may be used to make a quick attack on a fire whilst other gear is being organised from the appliance.

Where marinas or boatyards have facilities for laying up boats for the winter there is the risk presented by a large number of yachts and boats being stored close together, many propped up with timber shores. Boats could be as small as 6 metres or as large as 18 metres, some with masts up to 15 metres high. Most of the boats will have fuel in the boat's tank and probably some more in plastic containers, plus gas bottles used for cooking. Fuel

Photo. 9.3
Boatyard fire – shows risk to adjacent yachts.
(Hampshire Fire and Rescue Service)

tanks and gas storage bottles can be located anywhere on the boat, but generally are to be found in the stern half of the vessel. Any fire in a yacht or boat in this situation has the potential to become quite hazardous (Photo. 9.3). The boatyard may be able to move boats away from a fire using their special boat lifting hoists but this takes time. Cooling sprays played on adjacent boats is likely to be the only safeguard against fire spread. There is always the added risk of a boat falling away from its supporting shores during firefighting or even afterwards.

9.2 Historic Ships

Interest in maritime heritage has resulted in the restoration of many famous vessels which subsequently become floating or dry dock museums. Usually such vessels represent a particular era in the country's maritime history and often no other example exists. Whilst such vessels do not present the risks generally associated with sea-going vessels, the type of construction and age of the vessels present unusual situations for firefighters. Some historic vessels are constructed of timber, some of steel and some are a combination of both (Photo's 9.4 and 9.5). There may be some form of fire main on the ship, but this may depend to some extent on whether such a facility would detract from historic originality. Extinguishers and/or hose reels are

Photo.9.4 Replica of Historic ship.

Photo. 9.5 Historic sail training ship.

Photo. 9.6 Type of vessel converted to floating restaurant/club. (HMFSI)

more likely to be found. The forms of construction are quite varied and are not included in this manual. However, where historic vessels are found the host brigade should ensure that firefighters visit the ships frequently to familiarise themselves with the type of construction and any special features which might have to be borne in mind should fire occur on the ship.

9.3 Floating Restaurants etc.

On some rivers or harbour areas will be found vessels converted for use as clubs, restaurants or house boats (Photo. 9.6). The vessels will probably have already given good service as functional seagoing or river pleasure craft, and their life is extended by the conversion. Such vessels are likely to have had the engines removed or they are inoperable. The conversion to meet the needs of the vessel's new role may not have been carried out to any marine construction standard, or have attracted any requirements under the building regulations. The degree of fire resistance of any new bulkheads, linings or decorative finishes may not perform as well as firefighters would expect of ship construction. However, the standard may have been influenced to some extent for means of escape purposes if a drinks or gaming license has been obtained. In such circumstances it can be expected that hose reels and hand extinguishers will be provided. Very often this type of converted vessel is moored fairly close to road access for customers or members, so it is probable that fire hydrants will not be far away.

In fighting a fire on a vessel such as described the officer-in-charge would need to be aware that the large open spaces used for dining and dancing could present a stability problem (free surface area) if jets are used without due consideration (see Chapter 4).

Chapter 10 – Training and Safety

10.1 Managing Marine Incident Safety

Serious marine incidents are a rare occurrence. Even those brigades which provide cover for ship fires have a limited opportunity to build up experience of such incidents.

As a result operational personnel are themselves unlikely to gain very much experience in ship firefighting.

It is therefore crucial that brigades have systems in place to ensure the safety of personnel who are to be committed to this infrequent and hazardous activity.

The Key Risk control measures that brigades will need to include to ensure **firefighting safety** must be pre-planned and will include:

- **Risk assessment**

An assessment will need to be made that takes account of the both the likelihood and the severity of any specific marine incidents. For fixed Special risks, for example docks and offshore facilities, site specific risk assessments may be required. For shipping it is likely that a more generic approach would be suitable.

- **Liaison**

Brigades will need to liaise with a number of external agencies both nationally and locally the agencies will differ depending upon the location and type of incident involved.

- **Pre-determined attendance of resources**

Having established the likely nature of any incident or type of vessel involved, the brigade will need to consider the level of response that would be appropriate. This will include the provision of specialist personnel, appliances, and equipment.

- **Local procedures and collaboration**

Significant marine incidents will require that all personnel and external organisations are aware of local arrangements for access, information etc. Collaboration with other brigades is likely to be required to ensure the availability of adequate resources.

- **Specialist operational information**

Brigades need to ensure, as far as is reasonably practical, that suitable and sufficient information relating to the hazards, risks and control measures is available to crews at the time of an incident. This may be achieved in a variety of ways but the information must be clear, concise, current and relevant. The information may be of a generic or specific nature.

- **Training**

Personnel who are likely to attend marine incidents, either at sea or in port will require specialist training. The training will be based on the outcome of the risk assessment and, to a great extent, the information contained within this manual. Learning outcomes will be both technical and practical and will be designed to satisfy the identified training needs of the individuals involved. Wherever possible, practical training should take place on the risk itself to enable fire-fighters to gain experience moving around in relevant structures.

The information contained within this manual provides firefighters with guidance relating to dealing with marine incidents. The information will also help brigades to preplan their organisational arrangements which will ensure, so far as is reasonably practical, the safety of operational

crews who have to deal with such unusual and arduous conditions.

● **Safe systems of work**

Safety procedures applied to normal land based incidents will generally continue to apply but additional factors need to be considered when training and dealing with ship incidents. These will include:

- Personnel should always wear approved lifejackets when using vessels such as tugs or launches to go out to and boarding moored vessels and also when aboard the ship. This will not be possible when wearing BA, and officers should bear this in mind in controlling movement aboard ships.

- Exercises in loading equipment on and off tugs and launches, boarding ships etc., will provide invaluable experience for firefighters.

- Actual progress down an escape ladder and through a shaft tunnel and engine-room will give firefighters more confidence in their ability to tackle an incident.

- Unless a ship is very small, laying guide lines (coloured tape, as opposed to a BA guide line where BA is used) to the fire area is always a good idea, especially on board passenger ships where, even without smoke, firefighters can become confused in the maze of decks and corridors (Photo. 10.4).

- When descending into engine rooms they should be aware that all ladders, landings and metal work are generally greasy, and take care how they proceed. They should also bear in mind that metal ladders may become hot, even at some distance from the fire.

- When climbing down into holds, firefighters should pay special attention to open hatches and remember not to step back off a ladder before checking that the ladder hatch is closed.

- When moving in smoke, they should bear in mind the whereabouts of coamings, open hatches, ducts and chutes and, if possible, mark them with lights or even have them guarded by a designated firefighter.

(a) Ships under repair

Ships undergoing repair, refit or refurbishment quite often have holes cut in the decks, companionways removed, loose electrical cables strewn everywhere, and many other hazards, e.g. flammable paints and liquids, gas cylinders, heaters.

Firefighters should make regular visits to ships in such 'conditions' in order to see the difficulties and carry out liaison and preplanning with the dockyard repairers.

Radioactive isotopes are sometimes used aboard ship and in repair yards. These risks should be identified and liaison with the repairers set up to ensure that firefighters receive adequate information on their whereabouts if called to an incident.

(b) Ships at quays or jetties

Approaching a ship at a quay or jetty can be hazardous, especially at night. Some jetties can extend half a kilometre off shore.

There are not always facilities for driving appliances down to the ship, and firefighters may have to walk, carrying equipment along narrow walkways which may be congested with pipelines, valves switchboxes etc. If these hazards cannot be illuminated, crews should be led to and from the ship with lights. (Photo. 10.5).

It is common practice for smaller craft (generally pleasure boats) to lie alongside one another, off jetties. Firefighters may have to clamber over two or three other vessels to reach an incident on an outlying one.

The difficulty of this manoeuvre will depend on the distance between the vessels, the sea conditions (choppy, swell etc), the amount of freeboard, and the extent of the general deck clutter, but firefighters should always exercise great care in passing from one vessel to another. They must keep their hands and feet clear of the sides to avoid being crushed, and should be careful in crossing gaps which are fluctuating in size.

Lifejackets should be worn at all times during the approach to the vessel involved.

10.2 Training

Where fire brigades have a significant port or shipping risk, or they are geographically suited to become involved in off-shore fire fighting they will establish a training package or include special sessions to ensure that personnel are properly prepared for what is generally considered one of the more arduous aspects of firefighting.

Training for port based incidents would involve the general principles of strategy and tactics of ship firefighting, which, if the brigade was likely to be called upon for off-shore incidents would need to be extended to cover the particular problems encountered in getting to the ship on fire and working in limited isolation.

(a) Training for Ship Firefighting in Port

● One of the most important training aspects for ship fire fighting is wearing Breathing Apparatus in heat and humidity on a regular basis. This can be further enhanced where there is access to a steel compartment BA chamber so that the proper effects of a ship fire can be re-created (Photo. 10.1). The use of guide lines and multiple entry points is also valuable training as it is often necessary to simultaneously enter a ship on different decks and from different directions.

● Ship construction covering the types of vessels regularly visiting the port needs to be included, both as basic class room sessions and practical visits. A good knowledge of the terms used to describe parts of a ship and actions on a ship save a lot of misunderstandings when dealing with a ship's crew members.

● Whilst firefighters will usually endeavour to use their own equipment on ship fires, a good understanding of the ship's own fire suppression systems and water main arrangement should be part of the instruction.

● A knowledge of the factors which affect a ships stability together with practical application on a simple model would confirm this aspect of ship firefighting. One of the most important stability considerations to be included is the effect of free surface water.

(b) Training for Off-Shore Firefighting

Personnel employed for firefighting at sea must be confident in the water, able to swim and should not be prone to sea sickness. The deployment of personnel in firefighting at sea will depend upon local circumstances. Whatever local arrangements are made, speed of response to assemble firefighters and equipment ready to be transported to sea is very important.

- Communications can be a problem on a ship. Valuable experience can be gained in carrying out communication exercises aboard ships to identify the possible problems and identify alternative arrangements.

- Regular practice with the use of thermal imaging camera equipment, should take place particularly during BA training.

All fire brigade personnel undertaking firefighting at sea must be properly trained and equipped for the purpose. The training should be part of routine training for those involved, and should include regular off-shore training exercises, in varying conditions so that those unsuited to off-shore operations will be identified.

Some of the measures and techniques which should be covered in training are listed below:

- Ship construction including fire protection and firefighting provision.

- Stability.

- Methods of boarding personnel and equipment by sea.

- Safety on board.

Photo. 10.1 BA training – Ship facility.
(Lothian and Borders)

Photo. 10.2
Exercising abandon ship by Kent fire-fighters.
(Kent Fire Brigade)

- Specialist firefighting techniques.
- Emergency evacuation procedures including use of lifeboats likely to be found on board ship. (Photo. 10.2)
- Heat and humidity training.
- Training in the use of helicopters including safety procedures, boarding and disembarking of personnel and equipment and winching drill. (Photo.10.3)
- Practical ditching training.
- Survival training including swimming.
- Communications systems, including marine band radio operator training.

This list is not comprehensive and brigades will use a risk assessment to help determine their training needs.

Photo. 10.3 Routine exercising with helicopter and tug. *(Kent Fire Brigade)*

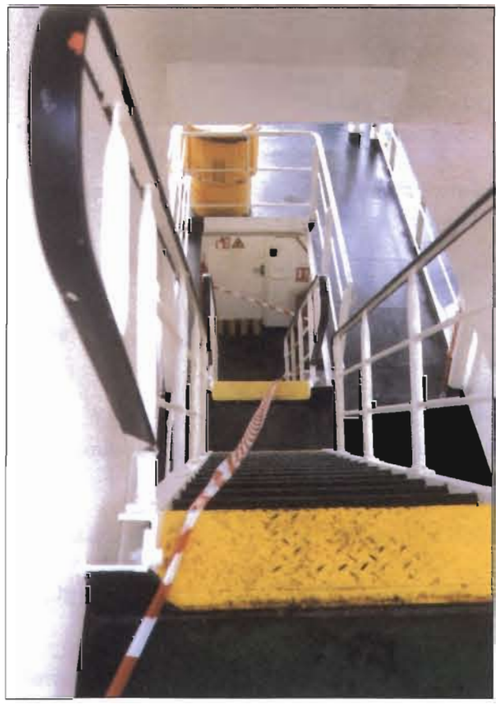


Photo. 10.4 (left)
Shows route to fire marked by coloured tape.
(A. Mechen)

Photo. 10.5 (below)
Shows long pier access to moored vessels.
Associated Petroleum terminals (Immingham)

Glossary of shipping terms

Abaft	To the rear of.
Abeam	A direction at right angles to the fore and aft line of a ship.
Accommodation ladder	A suspended staircase which can be lowered down a Ship's side to give access from water level to the main deck (sometimes wrongly called a companionway).
ADN	A European Agreement concerning the international carriage of Dangerous goods by Inland Waterways (translation).
After peak	The space within a ship directly in front of its stern.
Air draught	The height from the water line to the topmost part of the vessel.
Ahead	Directly in front of the bows.
Astern	Directly behind a ship.
Athwart	Across.
Ballast	Heavy material used to help keep a ship stable.
Battening down	Closing and securing hatch covers, originally referred to battens and wedges over canvas tarpaulins.
Beam	The width of a ship.
Bilge	The space towards the bottom of a ship, at the outer sides of the double bottom tanks, into which water drains from the bottom of the hold and, usually, from the tween decks.
Bilge sounding pipes	Pipes at the side of a ship, running from the upper deck to the bilges; there is one for each side of each hold.
Boat deck	The deck on which the lifeboats are located.
Booby hatch	A small hatch, separate from the main one, which usually gives access to a ladder.
Bows	The fore part of a ship (port and starboard).

Bridge The high part of a ship's superstructure from which it is primarily controlled.

Bridge deck A deck, level with the bridge along the top of the accommodation.

Brow Top of the gangway on an RN ship.

Bulk cargo A homogeneous, unpackaged cargo, e.g. grain, coal, oil, chemical for which the only containment is the ship's hull.

Bulkhead An internal wall, used to divide a ship into compartments. Bulkheads may be fire retardant or fire-resistant, and below the waterline athwartships bulkheads may be watertight.

Bunker A compartment in which fuel is stored.

Coaming Raised metalwork surrounding a hatch, or opening in the deck.

Coffer dam A narrow space within two watertight bulkheads separating two spaces.

Combination Carrier A ship designed to carry oil and other bulk cargo.

Companionway A staircase within a ship.

Condition The state of a ship in port – under repair, in dry dock.

Continuous deck One extending from stem to stern across the whole width of a ship.

Dampers Devices for blocking air ducts in the case of fire.

DSHR Dangerous Substances in Harbours and Harbour Areas regulations.

Deck One of the floors dividing a ship horizontally.

Deckhead The underside of a deck, forming a ceiling to the deck above.

Deep tank A tank in which liquid or dry cargoes may be carried in a dry cargo vessel. (It may be portioned off one of the lower holds.)

Derrick A type of crane on board a ship.

Double bottom A space under part or the whole of the hold and machinery spaces. It runs practically the whole length of a vessel and is divided into watertight compartments, some of which may be tanks for oil fuel.

Draught The distance from a ship's keel to the waterline.

Dumb barge A barge without its own source of power.

Epoxy A flexible thermosetting resin used in coatings.

Ferry A vessel providing a regular service between two ports for passengers and, in some cases, vehicles.

Fire main The water mains of a ship.

Flag Officer A senior naval officer entitled to fly a flag denoting his rank.

Forecastle (Fo'c'sle) The part of a ship's superstructure above the main deck at the bows.

Fore peak The space within a ship immediately behind the stem.

Frames Curved steel members running up the side of a ship to which the side plating is attached.

Free-board The height of a vessel's sides between the water level and the main deck. Sometimes referred to as the 'top-sides'.

Free surface effect The effect on a ship's stability of a tank or other space being partly, but not completely, full of liquid.

Galley A ship's kitchen.

Hard A stone or concrete extension to the foreshore which is uncovered at low tide.

Hard-arm A pivoted crane carrying flexible oil pipeline for loading and unloading tankers in preference to flexible pipes, they usually have a means of automatic shut-off and disconnection.

Hatch/hatchway An opening in a deck, perhaps to a cargo hold, with a raised coaming and means of being closed and made watertight. (The term hatchway refers to inside the open hatch).

Heel Of a ship: to lean to one side as the result of external force.

Hold An empty space within a vessel, used for the carriage of cargo.

Hull The main body of a ship excluding superstructure, masts etc.

IMCO Inter-Governmental Maritime Consultative Organisation: the earlier name of IMO.

IMO International Maritime Organisation: a specialised agency of the United Nations existing to provide means for co-operation and the exchange of information among governments on technical

	matters relating to international shipping, with special regard to safety at sea and the prevention of pollution.
Inclinometer	An instrument for measuring the angle of inclination of a ship.
Jacob's Ladder	A rope ladder with wooden rungs. Sometimes called a Pilot's ladder.
Keel	The lowest part of a ship, forming the backbone on which it is built.
Lee side	The side of a ship away from the wind.
Lighter	A cargo carrying barge which may take cargo from a ship to make it lighter, SEABEE and LASH ships carry lighters on ocean going voyages.
Liner	A large passenger vessel plying a particular long-distance route or undertaking leisure/educational cruises. (Now more commonly known as 'cruise ships').
List	Of a ship: to lean to one side as the result of the uneven distribution of weight within the ship.
LNG	Liquefied natural gas. A mixture of mineral gases consisting mainly of methane.
Loll	An inclination of a ship which may occur if the ship becomes marginally unstable in the upright position (see Chapter 4). (Note: It is not necessarily a sign of uneven weight distribution, and must not be confused with list. The two conditions require different methods of correction.)
LPG	Liquefied petroleum gas. A mixture of petroleum hydrocarbons consisting mainly of propane and butane.
Magazine	An area of a ship where ammunition is stored on a naval ship or explosives are carried in a merchant ship.
Manifest	A ship's list of its cargo.
MCA	Maritime Coastguard Agency
Master	The captain of a merchant vessel.
Mast house	A compartment built around a mast, which contains trunkways to the lower hold.
Monkey Island	A compass platform above the bridge.
MSDGR	Merchant Shipping Dangerous Goods Regulations

Perlite	A type of glass forming a lightweight aggregate, sometimes used as an insulating material.
Pilot ladder	Similar to a 'Jacob's ladder' only shorter.
Plug hatch	A specially designed insulating hatch used on reefer ships.
Pontoon	A floating structure which may be used as a buoyant support alongside a ship or mooring platform.
Poop	The after part of a ship. The poop deck is a raised deck at the stern.
Port	The side of a vessel on the left of a person looking forward.
Port-hole	A window in a ship's side or in a bulkhead usually circular.
Push-tow system	A system of barge propulsion in which the motorised vessel can either push or pull a string of barges.
Quarter	The part of a ship's side near the stern (port or starboard).
Reefer	Ship equipped with insulated and refrigerated holds to enable it to carry perishable goods.
Refrigeration	Method of cooling parts of a ship to enable it to carry perishable goods or, in some cases, liquefied gas at low temperatures.
Ribs	Curved members of the side of a ship running from keel to deck, to which the cladding of the hull is fixed.
Scuppers	Openings along the sides of a ship's upper decks to allow water to drain over the sides. Internal spaces may have scuppers which either drain over the side or lower down in the ship.
Shaft tunnel	A tunnel running from the engine room aft, containing the intermediate shafting between the engine and the propeller shaft at the stern. Modern all-aft ships may not have one.
Shell door	A watertight door opening in the ship's side shell plating for loading cargo or stores.
Shelter deck	A name given to the upper deck when the bulkheads do not extend to its underside but only to the deck below.
SOLAS	Safety Of Life At Sea.
Starboard	The side of a vessel on the right of a person looking forward.
Statutory bulkhead deck	The deck up to which watertight bulkheads must extend.

Stem	The vertical continuation of the keel at the bows.
Stern	The rear end of a ship.
Superstructure	The parts of a ship above the uppermost continuous deck.
Top-sides	The sides of a vessel between the water line and main deck.
Trim	The angle of a ship's fore and aft horizontal plane to the surface of the water.
Trimming hatch	A small opening sometimes found in the far corners of tween decks, away from the main hatches.
Tween deck	On a cargo ship, any deck between the upper deck and lower hold.
Tunnel Escape	A vertical means of escape from the shaft tunnel, usually at the after end, on an all-aft ship without a tunnel there will still be a protected means of escape from the bottom of the engine room.
Under way	A ship which is not made fast to the shore, at anchor or aground is under way.
Up-take	Flue taking exhaust gases from engines and discharging to open air.
Ventilation	Natural or mechanical means of supplying fresh air to an interior part of a vessel.
Weather deck	An open continuous deck.
Weather side (or Windward side)	The side of a ship towards the wind.
Wing tank	A tank high up on the side of a ship.

Further Reading

Fire Service Guides to Health and Safety

Volume 1 – A Guide for Senior Officers
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Acknowledgements

HM Fire Service Inspectorate is indebted to all who helped with the provision of information, expertise and validation to assist the production of this manual. In particular:

Allan E. Mechen Grad.IFE

Captain F.G.M. Evans BA FNI Grad.IFE Master Mariner Cert Ed.

Captain Robert G. Stollery, Marine Consultant

Commander B. Lambert RN

SDO Martin Muckett MBA, MIFireE, MIOSH

EUR. ING. Mike Pinder B.Sc. C.ENG. F.I.MECH. E. F.R.I.N.A. – Vice President of the Hovercraft Society.

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Cunard

Osprey Maritme (Europe) Ltd.

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The Harboour Masters Assoc. of UK, the Channel Islands and Isle of Man

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HM Coastguard

The Royal Institute of Naval Architects

The Environment Agency

Fire Check Consultants

British Waterways

Royal Navy – Phoenix NBCD school, H.M.S. Excellent

Chief and Assistant Chief Fire Officers' Association

The Fire Service College

Fire Brigades Union

Hampshire Fire and Rescue Service

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